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14

1905-1906

Transactions

OF THE

Association of Civil Engineers

OF

Cornell University

1906

The Cornell Inter-College Baseball Challenge Cup won in 1905 by the College of Civil Engineering

TRANSACTIONS

OF THE

ASSOCIATION

OF

CIVIL ENGINEERS

OF

CORNELL UNIVERSITY

VOL. XIV. 1905-6.

CONTAINING

ADDRESSES BY NON-RESIDENT LECTURERS, MISCELLANEOUS PAPERS, AND LIST OF MEMBERS OF THE ASSOCIATION

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TRANSACTIONS OF THE

ASSOCIATION OF CIVIL ENGINEERS,

CORNELL UNIVERSITY,

VOL. XIV, - - - - JUNE, 1906.

Copies of this and preceding issues can be obtained from Professor C. L. Crandall, Corresponding Secretary of the Association of Civil Engineers, Cornell University, Lincoln Hall, Ithaca, N. Y.

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PRESIDENT'S ADDRESS.

To the Members of the Association of
Civil Engineers, Cornell University.

GENTLEMEN :—

The lectures delivered before the Association during the past year have been as follows :

NON-RESIDENT LECTURERS.

Gen. William Sooy Smith, M.A.S.C.E. Consulting Engineer, Chicago, Ill. "Requisites for the Modern Engineer." Feb. 16, 1906.

Alberto F. Schreiner, '97. Assistant Engineer, Bureau of Sewers, Long Island City, N. Y. "Practical Design of Sewer Systems." March 2, 1906.

John C. Hoyt, '97. Assoc. M.A.S.C.E. Engineer, United States Geological Survey. "Work of Hydrographic Branch of U. S. Geological Survey." March 16, 1906.

M. N. Baker. Associate Editor, Engineering News. "The Relation of Engineers and Engineering Schools to the Work of Boards of Health." April 6, 1906.

Frank B. Sanborn, M.A.S.C.E. Professor of Civil Engineering, Tufts College. "Fire Protection of Factories." May 11, 1906.

H. H. Stoek. Editor of Mines and Minerals. "Preparation of Anthracite Coal for the Market." May 18, 1906.

RESIDENT LECTURERS.

E. A. Ekern, Instructor in Cornell Univ. College of Civil Engineering. "Power Development at Niagara Falls." Dec. 17, 1905.

F. J. Seery, Instructor in Cornell Univ. College of Civil Engineering. "Some Features of Isthmian Canal Projects." Jan. 19, 1906.

The regular Civil Engineering inspection trip was taken Nov. 27 to Dec. 2, by thirteen students and instructors under the lead of Prof. McCaustland. The following summary is taken from the report of G. C. Brown, Business Manager of the trip.

"The works inspected were, the excavations for the N. Y. C. R. R.

terminal, the Subway tunnels under the East River, the P. R. R. tunnel, Blackwells Island Bridge and the P. R. R. terminal in New York City. The Vulcan Iron Works and the Maxwell Colliery at Wilkesbarre. The Laurel Electric Road between Wilkesbarre and Scranton and the International Correspondence School at Scranton. The Cornell-Pennsylvania game was taken in on the way to Wilkesbarre."

"The entire party was given a very cordial welcome everywhere, great pains being taken to explain carefully all details of the works inspected. The cost of the trip was about $25.00, and was well worth the price as a valuable supplement to the regular college course."

The annual banquet of the Association was held on the evening of April the thirteenth, at the Ithaca Hotel. The guest of honor was Willard Beahan, '78. President Schurman and Professors McCaustland and Jacoby also spoke. The attendance was about 135. The committee in charge was, C. S. Rindsfoos, '06, Chairman, F. E. Lawrence, '06, E. D. Burnell, '06, G. L. Bilderbeck, '06, T. R. Stockdale, '07, G. D. Ellsworth, '08, T. W. Piollet, '09. Great praise is due them for making a rousing success of the banquet in the face of a great many difficulties.

Financially, the Association has beaten all previous records. More paid up members have been enrolled than ever before, and, at the end of the year, the Treasury shows a balance of $182.44 to be applied on the debt of $375.95, brought forward from last year.

The most important and successful development of the year was the innovation of holding the meetings in the evening, and providing, through subscriptions of nominal sums, refreshments to be served at the reception after the business meeting. The plan worked beyond anyones expectations. However, there are many improvements needed. In the first place, it is absolutely imperative that arrangements be made to hold the meetings in Lincoln Hall. With the increase of room to be made available by the shifting of the College of Architecture, it ought to be possible to get space for both the lectures and the receptions to follow. These receptions should be fostered as a valuable means of acquainting students and faculty with one another. The meetings should be more extensively advertised, particularly among the underclassmen. This will be possible only when the Appointment Committee makes out its list of lecturers a considerable time in advance of the meetings.

There are several other matters deserving a helping hand if the Association is ever to attain a strong and secure position. Mr. Job Rogers

has spent much time this year in obtaining from prominent manufacturing concerns, cataloges and handbooks to distribute among the graduating class. Much valuable matter can be obtained with little effort in this way, and it will mean much if this work is carried on in coming years.

The Transaction editors should aim to publish as many articles of original investigation by students or faculty as possible, and should try to encourage work for publication. The value of the book to our alumni and others depends largely on the new, engineering ideas we are able to put into their hands.

The Association, as the only organized body in our college, should see that our college teams are loyally supported, and should have pictures of all these teams hung in the building.

Last and most important, the interest of the undergraduates should be aroused in some way so that they will be pleased to prepare, present and listen to papers on engineering topics. Particularly should such interest be directed to narrower topics, subjects which can be covered in an evening definitely and plainly by students. Broad subjects in the hands of students can hardly be made interesting or profitable.

The thanks of the Association are due to the committees who have worked faithfully to shape the policies outlined above.

Trusting that the Association will continue in success and prosperity, we take pleasure in welcoming Mr. L. J. Sieling and his officers for the coming year.

Respectfully,

C. F. Cook,

President Association.

FUERTES GOLD MEDALISTS.

UNDERGRADUATES.

Albert Lloyd Colsten,	1895
William Mackintosh,	1896
Gilbert Powers Ritter,	1897
Harley Stuart Gibbs,	1898
George Wilfred Penfield,	1900
George Emil John Pistor,	1901
Albert Hotchkiss Chandler,	1902
Justin Wyman Ludlow,	1903
Ross Milton Riegel,	1904
John Earl Elliott,	1905

GRADUATES.

John Filmore Hayford,	1895
Elon Huntington Hooker,	1896
Erasmus Darwin Preston,	1897
John Cassam Wait,	1898
Frederic Eugene Turneaure,	1899
Clinton Brown Stewart,	1900
Edward Charles Murphy,	1901
Henry Robertson Lordly,	1902
William Kendrick Hatt,	1903
Anson Marston,	1904
Willard Beahan,	1905

The Fuertes gold medals are of a value of fifty dollars each, and are awarded under the following conditions :

The undergraduate medal "will be awarded annually to that student of the College of Civil Engineering who on graduating may be found by the faculty of the college to have maintained the highest degree of scholarship in the subjects of his course ; provided he has been in attendance at this University for at least two years."

The graduate medal "will be awarded annually to that graduate of the College of Civil Engineering who may write a meritorious paper upon some engineering subject tending to advance the scientific or practical interest of the profession of the Civil Engineer."

The papers shall be presented on or before April 15. If a paper is submitted in printed form, it will be received only provided it has not been published earlier than the last preceding April 15.

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CORNELL UNIVERSITY.

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CORNELL UNIVERSITY.

ALL GRADUATES OF THE COLLEGE OF CIVIL ENGINEERING UP TO AND INCLUDING 1906.

The address on the line with the name is the home or permanent one; that on the line below is the business or usually more temporary one. When only one is given its position is an index of its permanency, except when forced from one position to the other by lack of room. All the addresses have been verified since March 1, 1906, except those in italics, which are unreliable. All changes in address should be reported promptly to the Corresponding Secretary. The names of the deceased members are given at the end of the regular list.

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Commanding, U. S. C. and Geod. Survey Steamer Bache.
West, Ray B. . . . . *C.E.*, '06 . . . . . 2760 Wash. Av., Ogden, Utah.
Wheelock, Charles B. . . . . *C.E.*, '76 . . . . Boston, Mass.
Insurance, 107 Water St.
Whelpley, J. R. . . . . *C.E.*, '96 . . 2100 G St., N. W., Washington, D. C.
Asst. Engr., D. C. Engr. Dept.
Whiskeman, James P. . . . . *C.E.*, '98 ; Assoc. M. Am. Soc. C. E.
Civil Engr., Bur. of Bldgs., 180 W. 74th St. New York.
Whitbeck, Arthur S. . . . . . *C.E.*, '03 . . 27 Buckingham St., Rochester, N. Y.
Leveln., N. Y. S. Engr. Corps.

White, John S. . . . . *C.E.* ,'02.
Care Morse Chain Co., Ithaca, N. Y.
White, Timothy S. . . . . . *C.E.*, '73 ; M. Am. Soc. C E., M. E. Soc. W. Pa.
Vice-Pres. and Ch. Engr., Penn. Br. Co., Beaver Falls, Pa.
White, Willard O. . . . *C.E.*, '00 . . . . Blossvale, N. Y.
Asst. Engr , N. Y. S. Barge Canal, 225 N. Wash. St , Rome, N. Y.
Whitman, Ezra B. . . . . *C.E.*, '01 ; Assoc. M. Am. Soc. C.E., M. O. S. C.E.
Div. Engr., Disposal Plant, Sew. Com., Amer. Bldg., Baltimore, Md.
Whitson, Abraham U. . . *C.E.*, '99 ; Jun. Am. Soc. C. E. . Glen Head, L. I.
2nd Asst. Engr., Bur. Filtration, Pittsburg, Pa.
Wick, Richard B. . . . . *C.E.*, '81 . . . . . . 125 N. Vine St., Warren, O.
Engr., The Miller Const. Co.
Wight, Frank C . . . *C.E.*, '04. ; M Wash. Soc. C.E ; 948 Westminister St., N. W.
Asst. Resdt. Engr., Anacostia Br., Engr. Of., Washington, D. C
Wilcox, Clark L. . . . . *C.E.*, '01 ; Jun. Am. Soc. C. E.; Mexico, N. Y.
1st Asst. Engr., Bur. Filtration, Pittsburg, Pa.
Wilcox, Robert B. . . . . *C.E.*, '90 ; M. W. Soc. C.E.; 285 W. Adams St.
Superv'g. Engr., Dept. Boiler Inspection, Chicago, Ill.
Wilgus, Herbert S. . . . *C E* , '01 ; Assoc. M Am Soc. C.E.
Engr., Surface Lines, B. H. R. R., 166 Montague St., Brooklyn, N. Y.
Williams, Chauncey G. . . *C.E.*, '87 ; M. Am. Soc. C.E.
Contractor Gravity Water Supply, Lynchburg, Va.
Williams, Friend P. . . . . . *C.E.*, '99 . . . . 703 W. Sullivan St., Olean, N Y.
Asst. Engr., Barge Canal Office, Albany, N. Y.
Williams, Howard S. . . . . *C.E.*, '02 . . . . 401 Clinton Av., Brooklyn, N. Y.
Cleveland, O.
Williams, Roger B., Jr. . . . *C.E.*, '01 ; Jun. Am. Soc. C E., M.W.S E.
San. Engr., Pres., Williams, Proctor & Potts, 17 Battery Pl., New York.
Williams, Sylvester N. . . *C.E.*, '72. *A.M.* ; M Soc. P.E.Ed., M.I.E. Soc.
Professor, Civil Engineer, Cornell College, Mt. Vernon, Ia.
Williams, Tudor R. *C.E.*, '03 ; M. Scr. Eng., Cl ; 314 S. Main Ave., Scranton, Pa.
Asst. Engr., Scranton Ry., Co.
Wilson, W. Edward . . . . . *C.E.*, '01 ; Assoc M. Am. Soc. C.E.; Salt Lake City.
Civil and Cons. Engr., Asst. Prof. C. E., Univ. of Utah.
Windsor, Philip B. . . . . *C.E.*, '00
Marx & Windsor, Civil Engrs. & Surs., Box 114, Camagüez, Cuba.
Wing, Charles B. . . . . *C.E.*, '86 ; Assoc. M. Am. Soc. C. E., M. I.A.T.M.
Prof. Structural Engrg., Stanford Univ., Palo Alto, Calif.
Wing, Frederick K. . . . . . . *C.E.*, '90 ; Assoc. M. Am. Soc. C. E.
Civil Engineer, 910 White Building, Buffalo, N. Y.
Winship, Lef. . . . . *C.E.*, '05 . . . 125 Hamilton St., Penn Yan, N. Y.
Asst. Engr., Mo. Pac. Ry., Forest City, Ark.
Wolfe, Frank C. . . . . *C.E.*, '95 . . . . Union Bridge, Md.
Br. Dept., C. R. I. & P. Ry., Chief Drftn., LaSalle St. Sta., Chicago, Ill.
Wood, Rollin, ... *C.E.*, '06 . . . . . 429 W. Chas. St., Muncie, Ind.
Works, Norris M. . . . . . . *C.E.*, '97 . . . . Lima, N. Y.
Supt., Light House Dept., 537 Federal Bldg., Buffalo, N. Y.
Wright, George C. . . . . . . *C.E.*, '03 . Jun. Am. Soc. C.E., Ogdensburg, N. Y.
Representative, Unit. Concr. Steel Frame Co., Phila., Pa.

Young, Henry A. . . . . *C.E.*, '99 ; Assoc. M. Am. Soc. C. E.
205 Warfinton Ave., Yonkers, N. Y.
Engr., Ch. Const. U. S. Reclam. Ser., Huntley, Mont.

Young, Nathan E. . . . . *C.E.* '01 . . . . Owego, N. Y.
Asst. Engr., Hudson Riv. Realty Co., New York.

Zolzer, Charles H. . . . . *C.E.*, '01 . . 106 So. Portland Ave., Brooklyn, N.Y.
Ford & Waldo Contr., New York City.

Zarbell, Elmer . . . . *C.E.*, '95 ; Assoc. M. Am. Soc. C. E ; 4132 Ellis Ave.
Chicago, Ill.
Asst. Engr., c. Chief Engr's Office L. & N. R. R. Louisville, Ky.

GEOGRAPHICAL LIST.

NORTH AMERICA.

Canada. Total 6.

Montreal, Que.—E. T. Agate, R. A. Lockerby, H. R. Lordly. North Bay, Ont.—J. Aylen. St. John, N. B.—C. B. Brown, Jr. Truro, N. S.—O. H. Linton.

Mexico. Total 6.

Durango.—C. W. Comstock. Guaymas.—W. S. Pratt. Hornos.—C. A. Martinez. Ocampa.—M. F. Crossette. Santa Lucrecia.—C. B. Hobart. Topantepec.—F. F. Pino.

UNITED STATES.

Alabama. Total 3.

Holt.—C. M. Ayres. Mobile.—E. D. Burnell. Tuscaloosa.—A. H. von Bayer.

Alaska. Total 3.

Kiam.—C. B. Bacon. Seward.—W. G. Atwood, C. W. Harris.

Arizona. Total 3.

Morenci.—C. S. Gelser. Roosevelt.—H. Redmond. Tucson.—H. T. Cory.

Arkansas. Total 2.

Fayetteville.—J. J. Knock. Forest City.—L. Winship.

California. Total 18.

Bakersfield.—F. W. Warthorst. Berkeley.—F. F. Hall. Chula Vista.—E. L. Preston. Claremont.—G. F. Ferris. Merced.—H. C. Brown. Monrovia.—M. R Conable. Oakland —I. J. Coe, J. Page. Palo Alto.—C. D. Marx, C. B. Wing. Pasadena —D. J Macpherson. San Francisco.—E. Duryea, Jr., G. A. Ferguson, E. C. Johnson, N. B. Livermore, V. H. Poss, C. W. Raymond. Sausalito.—B. H. Fisher.

Colorado. Total 12.

Denver.—C. F. Allen, E P. Boynton, W. E. Greenawalt, R. B. Mildon, H.K. Runnette, J. Stearns. Georgetown.—F. A. Maxwell. Golden.—W. F. Allison. Grand Junction.—F. G. H. Schwalbach. Montrose.—I. W. McConnell, J. H. Miner. Silverton.—J. Dyson.

Connecticut. Total 10.

Berlin.—H. H. Bassett. Bridgeport.—R. W. Chase, Bristol.——F. Bruen. Collinsville.—L. Johnson. E. Berlin.—O. Benson. Hartford. C. H. Belden, A. S. Brainard. New Britain.—G. W. Penfield, M. A. Tenny. New London.—E. W. Kramer.

Delaware. Total 3.

EDGEMOOR.—M Rich. SYMRNA.—W. H. Janney. WILMINGTON.—J. E. Elliott.

District of Columbia. Total 19.

L. B. Fay, R. Follansbee, W. Greene, J. W. Griswold, W. G. Guss, W. G. Harger, J. F. Hayford, R. Herman, J. C. Hoyt, J. Michaelson, E. C. Murphy, S. Purcell, W. W. Reynolds, G. P. Ritter, R F. Shreve, H. L. Stidham, P. A. Welker, J. R Whelpley, F. C. Wight.

Florida. Total 3.

JACKSONVILLE.—R. B. Goodman, F. C. Phillips. OVIEDO.—T. L. Mead.

Georgia. Total

SAVANNAH.—F. E. Lawrence.

Idaho. Total 3.

BOISE.—A. P. Adair. CALDWELL.—E. Hedden. RUPERT.—C. M. King.

Illinois. Total 28.

ALTON —F. W. Olin. CHICAGO.—F. H. Avery, H. W. Baker, B. H. Bisbee, F. T. Conner, M. S. Darrow, H. O. Egeberg, W. B. Ewing, L. Faulkenau, R. L. Gifford, D. E. Hannan, C. A. Hasbrouck, A. H. Horton, A. M. Johnson, E. M. Lara, J. W. Ludlow, P. Ollason, M. E. Shire, E. C. Stone, J. Weatherson, R. B. Wilcox, F. C. Wolfe. DUQUOIN.—H. W. Swanitz. MENDOTA —F. W. Scheidenhelm. MT. CARMEL.—S. T. Neely. ROCKFORD.—A. E. Rutledge. ROCK ISLAND.—H. Parson. STERLING.—C. H. Bowen.

Indian Territory.—Total 1.

MUSKOGEE —M. A. Earl.

Indiana. Total 4.

LAFAYETTE.—W. K. Hatt, G. E. Waesche. MUNCIE.—R. Wood. TERRE HAUTE.—J. H. Weidman.

Iowa. Total 8.

AMES.—A. Marston. BURLINGTON.—W. B. Throop. CEDAR RAPIDS.—T. R. Warriner. CLARINDA.—W. C. Affeld. COUNCIL BLUFFS.—S. L. Etnyre. DES MOINES.—B. N. Moss, D. M. Rounds. MT. VERNON.—S. N. Williams.

Kansas. Total 3.

INDEPENDENCE.—C. R. Weidner. TOPEKA.—C. L. Hartwell. WICHITA.—R. H. Lockwood.

Kentucky. Total 5.

CLAY.—C. W. McCrea. COVINGTON.—W. H. Gelder. LOUISVILLE.—H. F. Scholtz, E. Zarbell. MORGANFIELD.—W. W. Olney.

Louisiana. Total 3.

ABBEVILLE.—W. Mackintosh. NEW ORLEANS.—C. W. Neville, Jr. SUN.—C. W. Coit.

Maine. Total 2.

PORTLAND.—I. W. Barbour, E. W. Gehring.

Maryland. Total 11.

ANNAPOLIS.—E. Brooks. BALTIMORE.—E. D. Cummings, A. V. Foard, L. J. Houston, H. E. Smith, C. R. Stine, E. B. Whitman. CUMBERLAND.—A. Silverman. FREDERICK.—R. L. Burwell. HAVRE DE GRACE.—F. S. Senior. FORT WASHINGTON.—W. R. Doores.

Massachusetts. Total 9.

ATTLEBORO.—W. I. Tuttle. BOSTON.—T. F. Bowes, E. J. Hadley, F. Parsons, C. W. Sherman, C. B. Wheelock. CAMBRIDGE.—W. L. Bowman. NORTH ADAMS.—H. E. Blake. WEST NEWTON.—I. T. Farnham.

Michigan. Total 9.

AGRICULTURAL COLLEGE.—H. K. Vedder. ANN ARBOR.—A. Adams. DETROIT.—W. J. Graves, R. B. Green, E. E. Haskell, M. S. MacDiarmid, K. B. Turner. ESCANABA.—W. W. Gaffin. HARBOR BEACH.—E. J. Duffies.

Minnesota. Total 11.

DULUTH.—T. D. Merrill, H. Thomas, O. A. Wait. HAWLEY.—A. C. Terrell. MINNEAPOLIS.—H. T. Eddy, S. W. Haas, J. J. Hankenson, R. A. Parke. ST. PAUL.—W. E. Bramhall, H. H. Thompson. WADENA.—H. W. Battin.

Mississippi. Total 1.

CLARKSDALE.—J. E. Craig.

Missouri. Total 16.

COLUMBIA.—T. J. Rodhouse. HANNIBAL.—G. A. Brown. JOPLIN.—C. B. Spencer. KANSAS CITY.—J. D. Bailey, J. C. Beye, S. E. Kelsey, A. H. Place. ST. LOUIS.—W. R. Bright, R. S. Colnon, G. I. Finley, R. P. Garrett, L. Highley, C. Hill, C. V. Mercereau, H. W. Pitzman, R. C. St. John.

Montana. Total 8.

BILLINGS.—E. D. Hendricks. BUTTE.—A. Frank, L. G. Gage, E. J. Strasburger. CHINOOK.—W. B. Freeman. GLENDIVE.—W. L. Curtis. GREAT FALLS.—W. C. Smith. HUNTLEY.—H. A. Young.

Nebraska. Total 4.

HAIGLER.—W. H. Larned. LINCOLN.—A. S. Tibbets. OMAHA.—J. W. Towle. YORK.—W. J. Ryan.

Nevada. Total 4.

ELY.—G. W. Horner. HAZEN.—A. V. Saph. RHYOLITE.—J. C. Kennedy. TONOPAH.—J. C. Fassett.

New Jersey. Total 15.

CAMDEN.—M. deK. Smith. DUNELLEN.—W. Twining. EAST ORANGE.—W. R. Johnston. JERSEY CITY.—W. S. Edge, W. F. Farmer, L. Muller, W. M.

Torrance. MONTCLAIR.—A. Underhill. MORRISTOWN.—A. B. Lueder. MT. OLIVE.—S. W. Salmon. NEWARK.—J. P. Churchill, G. E. J. Pistor, C. S. Thatcher. ORANGE.—H. M. Freeman. ROSELAND.—P. L. Braunsworth.

New Mexico. Total 2

RATON.—A. H. Dunlap. SANTA FE.—R. Coltman, 3rd.

New York. Total 253.

ALBANY.—H. D. Alexander. A. C. Ashley, F. S. Dunn, L. R. Ellis, J. C. Finch, L. Garbi, Jr., C. R. Goodrich, L. S. Hulburd, J. H. Sturdevant, G. S. Tompkins, G. G. Underhill, C. W. Wasson, F. P. Williams. AUBURN.—J. B. McHarg BENSONHURST.—G. J. Steinacher. BOONVILLE.—A. M. Snow. BROOKLYN.—F. B. Alexander, L. F. Bellinger, J. A. Boorstein, LeV. M. Burt, A. H. Chandler, A. L. Colsten, E. J. Fort, E. Holmes, V. S Ingersoll, C. S Kelsey, H. Ryon, S. H Stebbins, W. R. Taylor, H. S. Wilgus. BUFFALO.—E. B. Bailey, F. V. Bardol, L. L. Davis, F. L. Dodgson, W. H. Dunham, E. A. Dushak, F. F. Gordon, H. R. Hoffeld, C. C. Huestis, A. R. Keller, G. H. Norton, O. M. Severson, J. E. Thebaud, N. O. Tiffany, G. O. Wagner, F. K. Wing, N. M. Works CANANDAIGUA.—G. W. Powell. CARTHAGE —J. P. Brownell. CATSKILL —E. Johnston. CHATHAM.—DeW. H. Daley. CHESTER.—T. F. Lawrence. COBLESKILL.—L. S. Rickard, DESPATCH —R. E. Curtiss. E. HAMPTON.—N. N. Tiffany. E. CREEK —B. Ehle. ELMIRA.—R. C. Beebe, E. A. Truran, C. R. Vanneman. FISH CREEK.—J. C. F. Shafer. FLINT.—G. G. Smith. FONDA.—D. F. Fulton. GROTON—E. A. Landon. HAMBURG —E. B. Butchers. HARTWICK.—G. L. Bilderbeck. HEMPSTEAD.—A. H. Seabury. HORTON.—F. E. Elwood. HUDSON.—R. J. Harding, C. G. Rossman. ISLIP.—E. R. Smith. ITHACA.—D. E. Andrews, F. A. Barnes, G. C. Brown, E. D. Button, I. P. Church, C. L. Crandall, E. A. Dahmen, J. C. Davis, A. J. Edge, S S. Garrett, H. A. Gehring, S. G. George, F. L. Getman, E. Hayes, H. M. Hibbard, E. J. McCaustland, H. N. Ogden, R. M. Riegel, E. T. Turner, C. L. Walker, J. S. White. JAMAICA.—J. B. French. KINGSBRIDGE.—A. S Nye. LEEDS.—W. R. Vedder. LITTLE FALLS —J. N. Slater LONG ISLAND CITY—C. W. Haefner, Jr., W. L. Savacool, A. F. Schreiner. MACEDON.—A. B. Bullis. MCGRAWVILLE.—M. C. Bean. MAINE.—S. E. Hunt. MARATHON.—H. E. MACK. MILLBROOK.—A. H. Haight. MONROE.—F. J. Knight MT. VERNON.—N. B Reardon. NEWARK —C. L. Kelley, S. L. Tuttle NEW HAMBURG.—H. E. Fraleigh, T. Howard. NEW YORK CITY.—H. G. Balcom, C. L. Barton, H. K. Bishop, N. S. Blatch, J. A. Boorstein, T. B. Bryson, J. P. Carlin, F. W Carpenter, A E Clark, T. S. Clark, A. A. Conger, A. S. Crane, N. Cummings, W. J Darrow, R. C. Dennett, G. Devin, J. H. Dickinson, D. Y. Dimon, D. H. Dixon, J. L. Dodge, P. G. Douglas, J. H. Edwards, O. M. Eidlitz, G. W. Ellis, E. W. Firth, E. A. Fisher, F. W. Fisher, W. S. Fitz-Randolph, G. M. Forrest, T. L. Fountain, J. H. Fuertes, W. E. Fuller, D. S. Greeley, C. N. Green, C. Greene, R. W. Havens, H. C. Henderson, A. H. Higley, J. C. Hilton, E. H. Hooker, H. N. Howe, S. C. Hulse, H. B. Hurlbut, A. C. Hutson, R. H. Jacobs, B. Jones, R. H. Keays, W. D. Kelley, J. A. Knighton, H. Kratzenstein, C. W. Landis, R. Lewis, E. B. Lovell, L. McHarg, G. E. Malone, C. W. Marsh, O. Merrill, C. W. Myers, E J. Moore, F. C. Moore, H. G. Northrup, A. B. Osborne, E. H. Owen, R. S. Palmer, R. A. Pendergrass, C. N. Pinco, C. Potts, C. U. Powell, R. F. Proctor, J. E. Read, J. W. Reed, A. B. Rider, J. W. Ripley, A. Rodriquez, J. R. Rogers, F. J. Root, M A. Rue, W. H. Schmidt, E. E Seelye, A. K. Shumway, G. F. Simpson, F. W. Skinner, W. C.

Spiker, F. S Storey, W. H. Stratton, J. S. Swindells, G. Tatnall, W. T. Taylor, S. P. Thomas. E D. Thompson, F. C. Tolles, H C. Tompkins, F. M. Towl, W. E. Truesdell, C. P. Utz, E. Viertels J. E. Wadsworth, B. H. Wait, J. C. Wait, J. P. Whiskeman, R. B Williams, Jr., N. E. Young, C. H. Zolzer. NIAGARA FALLS.—H. I. Bell, H. W. Dennis, E. E. Haslam W. W. Read. NORTH ROSE —A. Weed. OSWEGO.—F. W. Ormsby, C. H. Snyder. OWEGO.—C. T Chapman, C. S. Mallery. PETERSBURGH —H. E. Green. PHILADELPHIA.—C L. Becker. PLEASANT VALLEY.—R. B. Upjohn. POUGHKEEPSIE.—A. Thompson, Jr. ROCHESTER.—N. A. Brown, C. W. Curtis, G. E. Gibson, J. D. Justin, J. F. Skinner, W. R. Storey, A. S. Whitbeck. ROME —M. B. Palmer, W. O. White. SANDY HILL.—W. C. Trumbull SCHENECTADY.—R. Mayhew. SKANEATELES—C. E. Mollard. SYRACUSE.—W. M. Butler, W. S. Farrington, G. D. Holmes, M. D. Makepeace, T. McE. Vickers. UTICA.—C. F. Cook, H. E. Golden, R. H. Knowlton, H. V. Owens, H. G. Throop. WADDINGTON.—H. W. Rutherford. WATERFORD —E. Hilborn. WATERTOWN.—W. J. Durkan. WATKINS —S W. Webb. W. NEW BRIGHTON.—W. Brown. YORKSHIRE.—H. E. Weatherlow.

North Carolina. Total 1.

WINSTON-SALEM.—O. H · P. Cornell.

Ohio. Total 34.

ADENA.—T. W. Hill CINCINNATI.—E. W. Hyde, L. G. Schreiber, C. M. Stegner. CIRCLEVILLE.—C. S. Rindsfoos. CLEVELAND.—J. A. Baum, W. Beahan, F. E. Bissell, W. P. Boright, C. H. Clark, L. D. Conkling, T. M Foster, E. E. Hart, A. J. Himes, A. S. Mirick, L. A. Mitchell, J. A. Skinner, C. A. Snider, H. W. Strong, L. P. Tier, B. E. Tilton, M. Warner, H. S. Williams. COLUMBUS.—R. H. Simpson. DAYTON.—N. J Bell. GALION.—J. G. Shillinger. IRONTON.—F. C. Tomlinson LIMA.—J. L. Dowling. SANDUSKY.—I. C. Brewer. TOLEDO.—C. S. Davis, A. B. Loomis, W. J. Sherman. WARREN.—R. B. Wick. YOUNGSTOWN.—C. B Sill.

Oregon. Total 4.

OREGON CITY —H. G. Turner. PORTLAND —G C. Cummin, W. S. Dole. SALEM —J. H. Lewis.

Pennsylvania. Total 94.

AMBRIDGE.—C. A. Kain, W. C. Thomas. BEAVER FALLS —C. M. Emmons, B. M. Latting, T. S. White. BETHLEHEM.—S. M. Turrill. CLARION.—J. C. L. Fish. CRAFTON —G. E. McCurdy, W. H. Tracy. ELKVIEW.—J. H Hutchinson. ERIE.—N. S. Crouch. FRANKLIN.—C F. Hamilton. GALETON.—S. E. Fitch. GREENVILLE.—D. B. Packard. HARRISBURG.—R. R. Fernow, M. G. Hilpert. HOMESTEAD —M. Haupt. JOHNSTOWN —C. E. Curtis, E. T. Gray, C. S Price. KINGSTON.—R. B. Howland, D. M. Rosser. LANCASTER.—W. W. Hoy, A. H. Kohn. MCCALL FERRY.—R. H. Anderson. MONONGAHELA.—G. F. Mueden NEW CASTLE.—G. Curtis, T. S Newman. OIL CITY —C. H. Lay, Jr., H. B. Robinson, G. F. Roess, G. O. Wallhauser, B. B. Weber, Jr. OSCEOLA MILLS.—H. E. Bertolet. OVERBROOK —J. P. P. Lathrop. PENFIELD.—C. A. Blakeslee. PHILADELPHIA.—L. Ashburner, M. A. Beltaire, Jr., I. C. Brower, C. W. Collins, C. Dillenbeck, C. W. Filkins, W. Fisher, R. P. Green, E. J. Hedden, T. C. Hu, S. I. Kehler, W. McKeever, J. J. Montgomery, S. M. Purdy, F. Schoff, L. J. Smith,

J. B. Thomas, J. C. Trautwine, 3rd, W. L. Webb, G. C. Wright. PHOENIXVILLE.—D. W. Bowman. PITTSBURG.—J. E. Banks, E. T. Brown, F. H. Clay, A. Curry, A. E. Duckham, A. R. Ellis, E. A. Evans, T. Fleming, Jr., E. D. Harshbarger, W. Jackson, E. E. Lanpher, B. M. Miller, J. N. Ostrom, H. F. Porter, C. M. Reppert, N. Schein, E. M. Sneckenberger, R. C. Taylor, H. W. Underwood, A. U. Whitson, C. L. Wilcox. PLYMOUTH.—W. P. Davenport. PORTAGE.—A. T. Hyde. RANKIN.—C. L. Bogart. SCRANTON.—G. G. Brooks, H. F. Cox, P. D. Hoard, W. H. Loomis, T. R. Williams. SLIPPERY ROCK.—A. E. Maltby. SUNBURY.—C. H. Niemeyer. UNIONTOWN.—H. B. Stevens. WARREN.—A. Rogers. WILKES BARRE.—J. H. Lance, G. E. Long, J. F. Storz. WILKINSBURG.—L. M. Sanford.

Rhode Island. Total 2.

MANVILLE.—W. I. Vose. PROVIDENCE.—J. E. Hill.

South Carolina. Total 1.

CHARLESTON.—J. H. Dingle.

South Dakota. Total 1.

BOVINE.—J. L. Jacobs.

Tennessee. Total 6.

CHATTANOOGA.—L. B. Bryan, P. L. Pierce. MEMPHIS.—C. E. Boesch, C. E. Davis. NASHVILLE.—J. F. Brauner, Jr., F. S. Washburn.

Texas. Total 9.

AUSTIN.—G. M. Jarvis, T. U. Taylor. COLLEGE STATION.—J. C. Nagle. CORSICANA.—W. H. Page. EL PASO.—A. W. Hawley. FT. WORTH —K Robey. HOUSTON.—J. Cochran, D. K. Colburn. PALESTINE.—H. L. Erisman.

Utah. Total 9.

OGDEN.—R. B. West. OPHIR.—H. Gridley. SALT LAKE CITY.—G. M. Bacon, L. A. Cowan, R. R. Lyman, G. T. Morris, G. Sterling, R. J. Taylor, W. E. Wilson.

Vermont. Total 1.

MONTPELIER.—H. Corbin.

Virginia. Total 4.

HOUSTON.—W. Bouldin, Jr. LYNCHBURG —C. G. Williams. NEWPORT NEWS.—C. W. Ashley. RICHMOND.—H. Pierce.

Washington. Total 11.

MT. VERNON —J. W. Meehan. SEATTLE.—C. H. BAKER, A. S. Downey, A. H. Fuller, R. E. Marvin, C. C. Moore, E. J. Pearson, C. N. Reitze. SPOKANE.—J. C. Breedlove, P. D. Coons, F. J. Engel.

West Virginia. Total 1.

PARKERSBURG.—W. H. Gerwig.

Wisconsin. Total 8.

GREEN BAY.—P. Strang. MADISON.—G. J. Davis, Jr., D. W. Mead, C. B. Stewart, F. E. Turneaure. MILWAUKEE.—H. F. Badger, Jr. OSHKOSH.—L. M. Mann. SUPERIOR.—P. H. Perkins.

Wyoming. Total 3.

CODY.—A. H. Perkins. PATHFINDER.—E. H. Baldwin. WALTON.—A. E. Rommel.

CENTRAL AMERICA.

Panama. Total 5.

ANCON.—F. H. Masters. BAS OBISPO.—J. Hayes. BORAS DEL TORO.—J. H. Stubbs. COLON.—R. Dominquez. CULEBRA.—J. G. Sullivan.

SOUTH AMERICA.

Brazil. Total 3.

CEARÁ.—A. E. Frota. SAO PAULO.—C. P. Barros, D. C. Moraes.

Ecuador. Total 1.

QUITO.—H. F. Hamlin.

Uruguay. Total 1.

MONTEVEDEO.—C. C. Lewis.

WEST INDIA ISLANDS.

Bahamas. Total 1.

NASSAU.—E. George.

Cuba. Total 10.

CAMAQÜEZ—E. Marx, P. B. Windsor. CHAPARRA.—M. G. Menocal. HAVANA. —F. Landa, F. de P. Rodriquez, M. A. Smith, C. C. Torrance. LA MARGUE.—J. P. Urner. MACAGÜA.—H. C. Ruiz. ———.—J. M. Haag,

Isle of Pines. Total 1.

COLUMBIA.—L. C. Giltner.

EUROPE.

France. Total 1.

PARIS.—J. J. Klaber.

Great Britain. Total 1.

MIDDLESBROUGH, ENG.—A. M. Mosscrop.

ASIA.

Japan. Total 2.

TOKIO.—T. Nambu, B. Sugi.

Philippine Islands. Total 12.

LUZON.—V. R. Stirling. MANILA.—A. F. Armstrong, J. W. Beardsley, W. E. Conklin, H. C. De Lano, O. W. Ferguson, A. Gideon, H. E Hyde, O. L. Ingalls, C. H. Kendall, H. Krusi, J. A. Vogleson.

AUSTRALASIA.

Australia. Total 1.

ADELAIDE.—W. H. Ledger.

Address Unknown. Total 14.

H. C. Brown, G. W. Dean, H. A. Gilmore, H D. Halbert, H. C. Hopkins, J. Kiddie, D. T. Lawson, C. H. McCormick, M. A. Monge, J. del C. Munoz, L. Paz, F. H. Potter, F. X. da Silviera, D. D. Sprague.

Total Membership	731
Deceased Members	60
Total Graduates	791

DECEASED MEMBERS.

NAME		RESIDENCE	DATE OF DEATH
Ames, Willis C	*C.E.*, '77	Whitney's Point, N. Y.,	Feb. 23, 1894
Aylen, Charles P.	*C.E.*, '76	Aylmer, Canada,	April, 1894
Brown, Allen J.	*C.E.*, '96	Oswego. N. Y.,	April 7, 1903
Bueno, Francisco de A V.	*C.E.*, '76	Rio de Janeiro, Brazil,	About 1881
Burns, Justin A.	*C.E.*, '92	Watertown, N. Y.,	Nov. 14, 1905
Carpenter, Frank DeY	*C.E.*, '73	*M.C.E.*, '76; Highland, N. Y.,	Dec. 19, 1883
Chase, Arthur R	*A.B.*, *C.E.*, '05	Sioux City, Ia,	Dec. 7, 1905
Clark, Dan. B.	*C.E.*, '93	Newtonville, Mass.,	May 20, 1904
Clark, Frank B.	*C.E.*, '96	Fulton, N. Y.,	Oct. 29, 1899
Clark, Ira E.	*C.E.*, '72	Weston, Mass.,	May 23, 1882
Cook, Isaac N.	*C.E.*, '75	Jersey City, N. J.,	May 7, 1885
Cooper, Edgar H.	*C.E.*, '85	New York City,	Oct. 1890
Couch, Vinton M.	*C.E.*, '92	Odessa, N. Y.,	Nov. 4, 1901
Dimon, Henry G.	*C.E.*, '87	New Rochelle, N. Y.,	Jan. 9, 1902
Dodraluboff, John A.	*C.E.*, '74	Nijni, Novgorod, Russia,	About 1882
Dodd, Franklin M. G.	*C.E.*, '90	Franklin, N. J.,	Sept. 13, 1891
Doerflinger, Augustus	*C.E.*, '71	Brooklyn, N. Y.,	Nov. 24, 1899
Eidlitz, Alfred F.	*C.E.*, '76	New York City,	April 22, 1877
Enos, George W	*C.E.*, '96	Chaumont, N. Y.,	Nov. 3, 1905
Farnham, Whitfield	*C.E.*, '71	*M.C.E.*, '74; St. Louis, Mo.,	April 13, 1895
Ferguson, Nicholas C.	*C.E.*, '79	St. Louis, Mo.,	Sept. 22, 1896
Fisher, B. H.	*C.E.*, '85	Sausalito, Cal.	May 27, 1906
Fisher, Nathan S.	*C.E.*, '99	Norwich, N. Y.,	Aug. 29, 1900
Fitch, William R.	*C.E.*, '74	Ithaca, N. Y.,	April 14, 1886
Foster, Reuben B.	*C.E.*, '74	*M.C.E.*, '77; S. Lake Weir, Fla.,	Nov. 7, 1895
Frost, Arthur B.	*C.E.*, '01	Ithaca, N. Y.,	Mar. 7, 1902
Frost, Frederick W.	*C.E.*, '72	New York City,	Oct. 3, 1899
Geigel, Antonio S.	*C.E.*, '92	San Juan, Porto Rico,	Jan. 17, 1901
Gibbs, Harley S.	*C.E.*, '98	Pittsburg, Pa.,	Aug. 8, 1899
Gilbert, Warner W.	*C.E.*, '95	Rochester, N. Y.,	May 19, 1901
Gillette, Olin C.	*C.E.*, '71	Atlanta, Ga.,	Jan. 25, 1901
Greene, Almon C.	*C.E.*, '75	Palmyra, N. Y.,	July 28, 1897
Guinn, John B.	*C.E.*, '92	Joplin, Mo.	May 1905
Gunner, Daniel W.	*C.E.*, '87	Schagticoke, N. Y.,	Oct. 10, 1887
Hallock, E. Allen	*C.E.*, '91	Moriches, N. Y.,	April 13, 1900
Hasbrouck, Alvah D.	*C.E.*, '88	Highland, N. Y.	July 5, 1904
Hitz, Irving	*C.E.*, '91	Chicago, Ill..	Sept. 24, 1901
Holbrook, Ernest M.	*C.E.*, '89	*M.C.E.*, '90; Ithaca, N. Y.,	Oct. 9, 1892
Hulse, Howard C.	*C.E.*, '91	Brooklyn, N. Y.,	Feb. 20, 1893
Jordao, Elias F. P.	*C.E.*, '74	Sao Paulo, Brazil,	March 25, 1901
Landers, Herbert H.	*C.E.*, '90	Green Island., N. Y.,	Feb. 4, 1893
Lyman, George F.	*C.E.*, '73	Tenafly, N. J.,	Dec. 25, 1880
MacMullen, Justus C	*C.E.*, '76	Unionville, N. Y.,	Jan. 31, 1888
Moore, Clarence S.	*C.E.*, '98	Olean, N. Y.,	July 7, 1900
Park, Robert B	*C.E.*, '94	Athens, Pa.,	Aug. 24, 1905
Peck, William T.	*C.E.*, '02	Bristol, Conn.,	Sept. 12, 1905
Preston, Erasmus D.	*C.E.*, '75	*M.C.E.*, '80; Wash., D. C.,	May 8, 1906
Preston, Kolce	*C.E.*, '73	Wilmington, Del.,	Jan. 4, 1876
Rogers, Jesse A.	*C.E.*, '91	Evans Mills, N. Y.,	April 24, 1897
Seidell, William C.	*C.E.*, '04	Peterboro, N. Y.	Dec. 28, 1904
Shaler, Ira A.	*C.E.*, '84	*M.C.E.*, '86; New York,	June 29, 1902
Sheldon, Daniel C.	*C.E.*, '83	Delphi, N. Y.,	Oct. 2, 1893
Shepard, Frank W.	*C.E.*, '86	Medina, O.	Feb. 10, 1892
Smith, George La T.	*C.E.*, '71	*M.C.E.*, '74; Canandaigua, N.Y.,	June 25, 1892
Smith, William J.	*C.E.*, '79	Charleston, N. Y.,	Dec. 3, 1886
Stewart, Neil, Jr.	*C.E.*, '87	York, N. Y.,	March 30, 1891
Tilley, George A.	*C.E.*, '73	Washington, D. C.,	March 14, 1877
Tompkins, John H.	*C.E.*, '73	Poughkeepsie, N. Y.,	July, 1879
VanCauteren, Emile A.	*C.E.*, '97	Pringy, Seine-et-Marne, France,	July 4, 1898
Viegas-Muniz, Joaquin	*C.E.*, '77	Pirocicaba, Brazil,	About 1883
Wightman, Willard H.	*C.E.*, '81	Ashland, Ore.,	Oct. 29, 1889

IN MEMORIAM.

JUSTIN J. A. BURNS, '92.

In the death of Justin Jerome Ambrose Burns, C. E., '92, at Watertown, N. Y., on November 14, Cornell lost one of the most prominent alumni that has been given to the world by the College of Civil Engineering since its establishment. In the fifteen years since his graduation, Mr. Burns had been engaged in some of the greatest engineering works of the time, and the practice of his profession had carried him completely around the globe.

Mr. Burns was born in Watertown, July 28, 1870. He obtained his early education in the Watertown public schools and in the High school of that city, and entered Cornell in 1888 at the age of eighteen years. He had won a state scholarship, and earned the remainder of his expenses at college through his talent as a musician, playing first violin in the orchestra and at the Lyceum theater. Professor George W. Cavanaugh, '96, who was his room-mate during the four years of his college life, says he has never known so tireless a worker. Day after day Mr. Burns would arise at 5 o'clock in the morning to study, after being kept out until after midnight the evening before by his musical work.

After leaving Cornell Mr. Burns secured a position on the construction of the Third avenue cable road in New York city, where he remained for two years. At the end of that time he went to Grand Rapids, Mich., to enter the service of the Detroit, Lansing & Northern railroad, as the Pere Marquette was then called. He had been in the West only a year, however, when he tried a civil service examination for the position of assistant chief engineer of bridges for the borough of Bronx, New York. He won the position, attaining the remarkable record of 99 per cent. in the examination, and remained in this position until the outbreak of the war with Spain in 1898. He enlisted in Company M, 1st regiment of volunteer engineers, U. S. A., and after serving as a clerk in the recruiting office at Peekskill, went to Porto Rico as 1st sergeant major of his regiment, being later promoted, at the request of the officers of the regiment, to the rank of 2nd lieutenant.

Upon his return to the United States at the close of the war, he was at once offered a position as civil engineer on the New York sub-

way and was placed in charge of the most difficult section of the work.

This included the famous loop around the City hall, regarded as one of the most wonderful engineering feats accomplished in the construction of the entire subway. When he had finished this work, he was appointed one of the three assistant chief engineers of the American-Chinese railroad, at the request of Chief Engineer Parsons, who had noted with approval his achievements in the subway. Mr. Burns dug the first spadeful of earth in the construction of the railroad from Canton to Hankow, and remained in China, in active charge of one of the most difficult parts of the work, for a year and a half, until the Boxer uprising put a stop to the work and forced him to flee the country. On his way home he completed the circuit of the globe coming by way of Europe and the Atlantic.

After his return he was engaged, until last summer, on the construction of extensive street railway systems in Memphis, Tenn., involving an expenditure of more than $8,000,000. Having completed this work, he had returned to his home in Watertown for a short rest before taking up his next commission, the building of the tunnel under the East river for the Pennsylvania railroad. He became ill of typhoid fever on November 1, and died November 14. He was buried at Watertown, N. Y.

During the past few years Mr. Burns had been a frequent contributor to engineering periodicals, his articles on the railroad in China which appeared in the *Engineering News* being the best known. He was a man of versatile accomplishments, and seemed to have the ability to excel in whatever he undertook. At the time of his death he possessed a speaking knowledge of French, German, Spanish and Italian, and had considerable acquaintance with the Chinese language. He was unmarried, and both his parents are dead. He is survived by five brothers and two sisters.

ARTHUR R. CHASE '05.

Arthur Reynolds Chase, the youngest son of Reverend James B. Chase and Mary Reynolds Chase was born at Weeping Wake, Nebraska, January 5th, 1876. He first attended primary school at Cherokee, Iowa, his grade work was done in Sioux City, Iowa, schools. He prepared for Iowa College at the Hill Academy entering college in the spring of 1891, and obtaining his A. B. degree in the class of 1895. When at Grinnell he was the editor of the college paper, "Scarlet and Black."

After graduation, Chase spent four years from 1897 to 1901 teaching in the Hill Academy, during the last two years of which he was the principal of the academy. In the fall of 1901 he went to Rolla, Mo., and entered the school of mines and the following year he entered Cornell as a sophomore in Civil Engineering in the Class of 1905.

In the three years at Ithaca, Chase well merited the esteem and affection of his classmates and all those who came to know him. As a scholar of merit and as a big hearted gentleman, the memory of "Arsky" shall always be fresh in our minds. In the spring of his junior year he was appointed class computer, and in his senior year he was appointed one of the editors of the Transactions and to his efforts were due some of the beneficial additions and changes in that annual. While in college he was an active member of the Gamma Alpha society.

During five months after commencement, Chase was employed by Mr. Williams, contractor on the construction of a masonry dam near Lynchburg, Va. Early in November he received and accepted an offer of the position of transitman in the tunnels of the Hudson River Improvement Co. of Jersey City. And it was while in the employ of this company that he met his sudden and dreadful death.

On the fourth of December at about 11 A. M., Chase and another young engineer attempted to leave the tunnels by the material elevator operating in the New York City shaft. Just as the cage was stopping at the ground level and immediately after his fellow passenger had stepped to safety, without a moment's warning the lifting cable pulled out of the lug in the top of the cage, and the lift, bearing Chase, fell ninety feet to the concrete floor below. His skull was fractured and death was instantaneous. His body was interred at Sioux City, Iowa.

GEORGE W. ENOS, 1896.

George W. Enos was born ar Chaumont, New York, on November 26, 1874. He was graduated from the College of Civil Engineering at Cornell University with the class of 1896.

After graduation he was employed until December 1896 as inspector and transitman on the construction of a sewerage system at Ithaca, N. Y., and from that date until August 1897 as assiatant in the Maintenance Department of the Syracuse Rapid Transit Company. From August, 1897, to August, 1898, he occupied a position as engineer and assistant superintendent under Major Ira A. Shaler on the reconstruc-

tion of underground electric railroads in New York and on the construction of government fortifications at Great Gull Island. From September, 1898, to October, 1899, he was Resident Engineer in charge of ten miles of electrical railroad construction near Albany, New York. In October, 1899, Mr. Enos engaged in the business of designing and installing contractor's plants and machinery, which business he continued until March, 1905. During this period he was connected with a number of engineering operations, among them being the foundation work for the Manhattan Power House and the installation of a plant for Major Shaler's section of the Rapid Transit Railroad, both in New York City. From March, 1905, until his death Mr. Enos held the position of Superintendent for the Turner Construction Co., in which capacity he had charge of the erection of a number of buildings in Brooklyn, N. Y. His death occurred in New York on November 3, 1905 and was accidental, he being instantly killed by an elevated train he was about to enter at the Grand Central Station.

His sudden death came as a great shock to the members of his class, and all who knew him, who had looked forward to his achieving a bright future. He was unmarried but is survived by his parents, two sisters and a brother.

ROBERT BRUCE PARK, '94.

Robert Bruce Park was born May 7, 1870, at Athens, Pa. He received his preparatory education in the public and high schools of that place and entered the College of Civil Engineering in Cornell University in 1890. He was graduated therefrom in 1894. For three years he was then engaged on structural designs for buildings and bridges with the Elmira Bridge Company at Elmira, N. Y. and with the Union Bridge Company at Athens, Pa. In 1898–99 he was Assistant Engineer with the Union Bridge Company, contractors for the Naval Coaling Station at Dry Tortugas, Florida, in charge of the foundations for this important structure. He returned to Athens in September, 1899, and remained with the Union Bridge Company until the following spring, when he was appointed by the U. S. Navy Department to inspect the erection of workshops and storehouses in the Navy Yard at Norfolk, Va. In September, 1901, he was transferred to the League Island Navy Yard at Philadelphia, Pa., where he was employed on designs for workshops, sea walls, piers, sewers, water systems, etc. In June, 1903, he was promoted to Draughtsman in charge of the office at this yard and in this position had supervision of the designs, plans,

estimates of materials and costs for the construction and repair of yard buildings, dry docks, sea walls, piers, paving and grading, sewerage, water supply, steam and electric conduits, and railways. He held this position until the time of his death.

He was thorough and systematic in his work and gave his full thought and attention to the duties at hand. He was especially complimented on the systematic arrangements of the work in the office at the League Island Navy Yard while he was there in charge.

In January, 1905, he successfully passed the examinations for Assistant Civil Engineer with the Panama Canal Commission and was in correspondence with the Commission when taken ill and a fine offer for his services at the Isthmus was received after his death.

He received a slight sunstroke while in Athens, Pa. on a vacation in July. He apparently recovered therefrom and returned to his duties in Philadelphia, but was taken ill again and went back to Athens and died there from congestion of the brain on August 24th, 1905.

In December, 1898, he married Miss Rita Myer of Athens, and she with a two year old daughter and his mother Mrs. L. M. Park, survive him. In his death, the College of Civil Engineering has lost an active and trustworthy alumnus, one who was true to his family, true to his duties, and true to his ideals.

WILLIAM T. PECK. '02.

William T. Peck was born September 30, 1879 at Bristol Connecticut. He entered the College of Civil Engineering at Cornell University in 1898 and was graduated in 1902. During his College course Mr. Peck showed unusual engineering aptitude. Thorough and conscientious in his work, his mind also exhibited that grasp and perspective, which would have enabled him to deal with the larger problems of the engineer. His ability was recognized by the Faculty in appointing him to a captaincy on the Junior survey.

After graduating from Cornell, Mr. Peck entered the Maintenance of Way Department of the Lehigh Valley R.R., where he performed the arduous duties of the railway engineer. His work included the preparation of plans and estimates for detailed track and terminal improvements, and the construction of bridge abutments and railroad structures. In the Fall of 1904 as the result of a competitive examination, he was called to take a position as Assistant Engineer to the Board of Rapid Transit R.R. Commissioners of New York City, but his health had already begun to fail, and he was unable to accept the appointment. In

July, 1904, he was obliged to retire from active work on account of illness, which rapidly developed into tuberculosis. On September 12, 1905, he died at his home in Bristol.

Mr. Peck possessed in large measure the confidence of his associates. Modest and unassuming in his manner, his career was full of promise. He was unmarried.

MYRON G. STOLP, '72.

Mr. Stolp was a member of the first class which completed a four-year course at Cornell, having graduated in 1872. As a student he was kind and genial, and he was beloved by all his classmates. He had a decided mechanical turn of mind, and while in college he invented a screw cutting lathe in which the pitch could be varied at will (within the range of the machine) by simply moving a lever. With the common screw cutting lathe only a fixed set of values can be obtained and that only by changing gears.

Afterwards he became interested in the theory of the injector for supplying steam boilers and he devoted much thought to the subject and spent a large amount of time in propounding his theory which differed from that commonly accepted. It is believed that he was lecturing upon this subject in New York when attacked by his last illness.

After graduating he was associated with his father for many years in their woolen mills. In 1891 he was appointed city engineer of Aurora, Ill., his native town, a position which he held for 12 years. As city engineer he had charge of the construction of the important viaduct crossing over the C. B. & Q. railroad tracks; he built many miles of brick paving, and he designed and built the very successful sewerage system which included some 60 miles of sewers. Upon the completion of his work as city engineer he was appointed supervising architect at the Boy's Home in St. Charles. Later he accepted a position on the Chicago Drainage Canal with head quarters at Lockport. This position he held for three years, resigning some two months before his death to attend to some business in New York. While there he delivered lectures to engineering societies which were well received.

While in New York he was taken ill and died of pneumonia in St. Luke's Hospital, on March 5, 1906, after one week's illness.

He was married in 1874 to Anna Gilbert, who survives him, as also two daughters and a son.

He was born in 1848 and was fitted for college at Oberlin.

Mr. Stolp always took a deep interest in public affairs and especially in the affairs of his native town. He was one of the city's leading musicians and was prominent in all the well known musical societies.

At the time of his death resolutions of respect were adopted by the members of the engineering department of the Sanitary District of Chicago, and also by the Board of Supervisors of Kane County, Ill.

ERASMUS D. PRESTON, '75.

Washington, May 8, 1906.

"The Superintendent announces with regret the death, at Tuscon, Arizona, on May 2nd, of Erasmus Darwin Preston, Assistant Coast and Goedetic Survey.

"Mr. Preston was born on March 28, 1851, in Lancaster County, Pennsylvania, and the preparation for his life's work is remarkable for its scope and character. In 1872 he graduated from the State Normal School, Millersville, Pennsylvania, with the customary degree in pedagogy and then proceeded to Cornell, where at the expiration of a three year's course, he received the degree of C.E., and after a year's occupation in the University as instructor in engineering, and further study was given his M.C.E. in 1880. The following two years were spent in a post-graduate course at the John Hopkins University, where he had been granted a fellowship; in 1878 and 1879 he was matriculated in the great French engineering institution, the Ecole des Ponts et Chaussees; and his university courses were completed by post-graduate studies in Goedesy, Magnetism, Force of Gravity, and Astronomy at the University of Vienna.

Entering the Survey 1879 as a computer, Mr. Preston's experience since has been a remarkably distinguished one, both in the office and field work of the Survey and in the detached duties upon which he has been employed. In 1882 he was attached to the French Transit of Venus Commission, and in 1883 he accompanied the U. S. Solar Eclipse Expedition to the South Pacific Ocean; granted a furlough for a year, he was employed as astronomer at the Cordoba Observatory in the Argentine Republic, and after his return, was sent, at the request of the Royal Government, to conduct the astronomical operations in the Hawaiian Island. In 1889 he went to Africa with the U. S. Solar Eclipse Expedition: and in 1891 was with the Transit of

Mercury Expedition, and co-operated in the International Latitude Work in Honolulu. In 1895 he became executive officer of the Coast and Geodetic Survey, in which position he continued until 1899, when he was appointed editor of the Survey publications, an office which he retained until, owing to failing health, he was relieved on his own application and sent to the field.

In 1898 he represented the United States as Delegate to the International Geodetic Association, which convened at Stuttgart. In addition to his professional acquirements, Mr. Preston was distinguished as a linguist; he was master of French, German, Spanish and Italian, a student of Latin, also of Polynesian and African dialects. These accomplishments and this versatility were demonstrated in nearly fifty papers published by him on subjects connected with astronomy, geodesy, magnetism, gravity and philology.

The death of so able and well equipped an officer involves a loss to the Survey that cannot be well estimated; for, a character that was in so many respects a shining and admirable exemplar was supplemented by acquirements of unusually high scholarship made fruitful by extraordinary diligence and energy, and although the harvest he leaves is a rich one, we feel it is but the promise of what he might have achieved.

O. H. Tittmann, Superintendent.

B. H. FISHER, '85.

Mr. B. H. Fisher, Cornell, '85, died at Sausalito, Cal., May 27, 1906, from tuberculosis. Mr. Fisher was Chief Engineer of the North Shore Railroad Company.

THESIS—1906.

MASTER OF CIVIL ENGINEERING.

Design for a Steel Mill Building, Jerome Cochran, B.S. and C.E.
The Flow of Water over Weirs as affected by the Width of Channel of Approach, William Franklin Martin, B.S. and C.E.

CIVIL ENGINEERING.

Philadelphia Filtration System, L. Ashburner.
Earthworks and Tables, G. L. Bilderbeck.
Road Constructing Machinery, W. Bouldin, Jr.
Flow through Vertical Pipes, P. L. Braunworth.
Effect of Curvature and Distance on Cost of Construction and Operation on the Ithaca, Elmira, Electric Ry., G. S. Brown.
Design of Dykes for Streams in City of Ithaca, N. Y., E. D. Burnell.
Testing of Reinforced Concrete Beams, L. M. Champaign.
Equipment of Large Railway Stations, R. Coltman,
Design of Flood Relief Channel for Cayuga Inlet, C. F. Cook.
Comparison of Meters, Floats and Weirs in Measuring the Flow of Water in open Channels, E. A. Dahmen.
Flow of Water through Specials, D. H. Daley.
Practice relating to, and Design of, Railroad Trustles, P. S. Douglas.
Flow of Underground Water, W. J. Durkan.
A Study of the Sewerage Disposal Plant of the City of Ithaca, E. A. Duschak.
Fuel Briquetting, F. E. Elwood.
Analysis of Weights of Short Span Railroad Riveted Bridges, E. A. Evans.
Design of Dykes for Streams in City of Ithaca, N. Y., L. B. Fay.
Design of a Concrete Steel, Circular, Dam, A. V. Foard.
The Percentage of Run-off to Rainfall, H. E. Green.
Economics of Grade Reduction, F. S. Gresham.

Water-borne Diseases ; Their Cause, Cost and Remedies, W. G. Guss.

Design of Mine Plant, D. E. Hannon.

Comparative Study of Stresses in Reinforced Arches [Design by the Elastic Theory and by the Three-Hinged Method,] Arches to be Spandrel Braced, M. Haupt.

Chemical Treatment of Timber for Railroad Ties, J. H. Hutchison.

A Critical Study of the Structural Details of Tall Steel Buildings, B. Jones.

Underground Haulage by Compressed Air and Electricity ; a Comparison, J. DeW. Justin.

Design for Sewer System for Saugerties, N. Y., G. B. Kelley.

Comparison of Meters, Floats and Weirs in Measuring the Flow of Water in Open Channels, R. H. Knowlton,

Comparison of Meters, Floats and Weirs in Measuring the Flow of Water in Open Channels, A. H. Kohn.

Sewer Pipe Design for the City of Cienfuegos, F. Landa.

Flow through Vertical Pipes, F. E. Lawrence.

Test of Reinforced Concrete Beams, O. H. Linton.

Economics of Grade Reduction on one of the Trans-Continental Railways, R. A. Lockerby.

Adhesion of Concrete and Steel, C. O. Martinez.

A Description of the Vulcanite Cement Plant and Test of a Griffin Grinding Mill, H. W. Pitzman.

Design of Flood Relief Channel for Cayuga Inlet, P. L. Pierce.

Comparison of Meters, Floats and Weirs in Measuring the Flow of Water in Open Channels, L. S. Rickard.

Investigation of the Deflection Curves of Railroad Bridges, as Affected by Sub-divided Panels, C. S. Rindsfoos.

A Review of the Manchester Experiments for the Disposal of Sewage, J. R. Rogers.

Test of Bierce and Stilwell Turbine of the Victor Type, and the rating of a Corresponding Wier to Measure Discharge, H. C. Ruiz.

Flow of Underground Water, H. W. Rutherford.

Water Softening Plants, W. J. Ryan.

A Study of the Loss of Head due to Flow Through Gratings, H. Ryan.

Tests of Reinforced Concrete, F. W. Scheidenhelm.

Design of Three-Hinged Arch-Ribs by means of an Imaginary Open Web System, N. Schein.

Design of Surface Plant for Kentucky Bituminous Coal Mine, H. F. Schaltz.

Tension Test on Reinforced Concrete, R. F. Shreve.

Comparison of Meters, Floats, and Wiers in Measuring the Flow of Water in Open Channels, H. E. Smith.

Design, Construction and Maintenance of Catch-Basins, A. M. Snow.

Comparison of Two Allignments on Lines of West Penn. R. R. J. Stearns.

Review of Experiments on Water Purification Conducted by the Cities of Louisville, Cincinnati, and Pittsburg. J. F. Storz.

Design of a Three-Hinged, Reinforced Concrete Arch, G. G. Underhill.

Foundations of Large Buildings, H. E. Weatherlow.

Tension Tests on Reinforced Concrete, S. W. Webb.

Effect of Drifting on the Elastic Properties and Tensile Strength of Mild Steel, R. B. West.

Wind Stresses in Knee-Braced Mill Buildings, R. Wood.

THE COLLEGE.

It has been thought by the editors of the Transactions this year, that perhaps a few words regarding the internal affairs of the College, and a brief outline of the interesting events of the year might not be out of place in a publication of this sort, but that such recital might be of real interest to many.

The attendance, which has been increasing steadily for some years, reached, this year, 425, of which 156 entered as freshmen and 15 are registered in the graduate department. 59 men are candidates for graduation in June of this year. This large attendance has made over-crowding in the building inevitable, but there is a slight rift in the cloud at the present time, since it is semi-officially announced that the College may expect to have the whole of Lincoln Hall for its own use next year, the College of Architecture probably finding domicile elsewhere.

Some changes were incorporated in the curriculum for this year, which seem, on trial, to be marked improvements. A three hour course in Engineeing Design, specializing in the field of hydraulics, railroads, bridges or mining, is offered to seniors, the student having freedom of election as to his field of work. The results of the first year's trial seem very encouraging. The courses in mining engineering have been so extended as to make it possible for a student to get fifteen university hours of strictly mining work in his senior year.

The geodetic and topographic surveys are now carried on at the end of the school year, the four and one-half weeks field work closing usually about July 7 to 10. The Fall Creek watershed, the field of operations since 1898, is now completed to the vicinity of Freeville. The camp of 1906 will provide for the accommodation and instruction of about 110 men. To properly instruct this large body of men, the instrumental equipment was increased this year by the purchase of ten new transits, two plane-tables and numerous minor instruments.

All the hydraulic laboratory equipment has been moved from the basement of Lincoln Hall to the Laboratory in the Fall Creek Gorge, and the space it formerly occupied has been fitted up for the testing of cements, thus furnishing a much needed relief from overcrowding in the old cement laboratory.

The Trustees have not yet appointed a Director to succeed Professor Fuertes, the office of Acting Director being still held by Professor Crandall. At the beginning of the year, Professor Mott resigned

from the College and accepted a place on the staff of the Mass. Inst. of Technology, his Alma Mater. No successor to Professor Mott has yet been appointed.

Mr. Fred Asa Barnes, '97, was, at the beginning of the year, appointed Assistant Professor of Railroad Engineering and Surveying. Professor Ogden was absent on leave during the latter half of the year. Some idea of the expansion of the work of the College may be gained from the statement of the fact that the staff of instruction was increased from nineteen to twenty-nine for this year's work. It is believed that the work of the College has never been better organized nor more successfully carried on than during the year just closing. The faculty work together in the utmost harmony, and the students, as a whole, seem animated by one desire alone,—to make the best possible use of the years they spend at Cornell.

LECTURES

AND

MISCELLANEOUS PAPERS.

ALUMNI REUNION.

PROCEEDINGS AND ADDRESSES.

A meeting of the Cornell Engineers was held in Ithaca, on Monday, June 19, 1905, as announced in the preceding number of the Transactions. The gathering was unique in that it was the first time that the Alumni of all classes of a single college had assembled on the campus during commencement week. The principal assembly room of Barnes Hall had been set aside for the occasion and the meeting was called to order at 10:00 A. M. About 43 of the Alumni were present and with the upper classmen and numerous ladies, made a goodly attendance.

The meeting was opened with an address of welcome by President Schurman. He expressed his cordial appreciation of this attempt to foster an interest in Cornell affairs and complimented the engineers upon their important part in spreading the Cornell fame. His welcome was most hearty and although other duties would not permit him to remain throughout the meeting he expressed his good wishes for a very interesting time and the hope that such reunions might occur annually hereafter.

The address was responded to by Albert J. Himes, '87, chairman of the meeting. In behalf of those present he expressed their pleasure that President Schurman had shown so much interest in the meeting, and extended their gratitude for his kindly welcome. He stated that the meeting was made possible by Professor Crandall, who since the death of Professor Fuertes, had been Professor in Charge of the College, and that its success was largely due to his efforts. Touching upon the affairs of the College, he urged a more active interest in its affairs to the end that through the influence and standing of the Alumni, it might in the future attain an even more commanding position than in the past.

The next feature of the meeting was a memorial address in honor of Professor Fuertes, delivered by Professor H. N. Ogden, '89. Professor Ogden spoke very feelingly of the work of Professor Fuertes and of the traits which had endeared him to his friends, and his remarks were listened to with the closest attention. At their close, he loosed the drapings of a bronze tablet that had been mounted on the platform, and as they fell to the floor the audience beheld, in bas-relief, a life-size bust of Professor Fuertes.

The tablet had been designed by Mr. Gutsell, and cast in the Sib-

ley foundry, and has since been mounted on the front of the Fuertes Observatory. It bears the motto "FIDELIS AD USQUE AD MORTEM".

Col. Henry G. Prout, Vice-President and General Manager of the Union Switch & Signal Co., was next introduced to the audience. Col. Prout had been chosen as one of the special lecturers for the year and had kindly arranged to give his lecture at this time. He spoke as follows :

COL. PROUT'S ADDRESS.

About two years ago an eminent engineer died in New York, Mr. Geo. Morison. He was a man of uncommonly broad education and of a powerful mind and illustrious achievement. Like most engineers he wrote but little, but he left behind him a manuscript which was afterwards printed in a book of 130 pages. You can read it easily in two hours, but it sums up much of the reading and meditation of a vigorous and intelligent life.

Mr. Morison reminds us that students have recognized certain great ethnical epochs in the progress of mankind. The use of fire first lifted man out of the condition of the animals around him ; then came the use of the bow and arrow which further established his superiority. The next great step was the use of pottery, and man passed from savagery to barbarism. The domestication of animals and the manufacture of iron marked two more eras in the development of the race. Finally came the use of the written alphabet, the greatest and most useful of all human inventions, by which knowledge could be preserved and distributed. Progress thus became continuous aud great masses of mankind were enabled to advance simultaneously along the same lines. This was the step from barbarism to civilization, and there the ethnical periods are considered to have closed. What has followed is assumed to be but the natural advance of civilization. But Mr. Morison thinks that there is no apparent reason why other epochs should not come just as distinct and just as important as either of the six which are behind us. It but needed the discovery or the development of a new capacity to make a new epoch, and such a new capacity came with the manufacture of power. By the development of the manufacture of power capacity is suddenly increased beyond any limit which the human mind can forsee or imagine. The strength of man or the strength of animals no longer sets a boundary to the capacity to do work. Forms of matter are changed, and the forces of nature are set to do man's bidding, and we can see no stopping place in this process. The power of man to do useful

work has been multiplied in the last century beyond all computation or imagining. In the last 100 years man's productive capacity has advanced more than in all the preceding years that he had inhabited this planet and the revolution wrought by the development of capacity to manufacture power has just begun ; the door has just opened.

In one voyage across the Atlantic a steamship developes as much power as was developed by hundreds of thousands of men working through decades of time to build the great pyramid ; but the biggest ocean ship is small compared with the great power factories which we can see all around us, and this power is delivered in our houses and in our shops and on our railroad tracks to the infinite saving of time and energy. It would interest you to try to compute the human effort saved by the mere fact that some hundreds of thousands of maids and housewives draw water from spigots, where it is delivered from steam pumps, instead of going to wells. How can we measure the effect on human society of the fact that two men in a locomotive cab haul 2000 tons of goods or 500 passengers across half a continent at 40 miles an hour, or the fact that every steam hammer in a forge shop does the work of a dozen men, and does it better.

While the capacity of Man, to do accustomed things has been multiplied, he has been empowered to do things that he could not have done before. The steel forgings that are made now could not have been made at all by man-power or animal-power. Manufactured power was necessary to the production of the great structures of today,—the ships, the guns, the bridges, the great engines in the power houses, the tall buildings in the cities. Perhaps there are those now before me who doubt if human happiness has increased by the mere capacity to produce big things. You will remember Ruskin's ideal society with the happy peasant in a velvet jacket singing in the fields, the heavens unpolluted by the smoke of mills and the air unvexed by the noise of railroads. Not long ago a professsr in a neighboring great university maintained with some heat, the superiority of the Greek civilization, when the mass of the people lived in squalor and built Parthenons, as compared with our civilization when the mass of the people are more sure of food and clothes and fuel, and build steel frame Masonic Temples. We cannot stop now to discuss the relative value of civilizations, but I make bold to believe that the average of human happiness was never so high as now.

The examples which I have cited only suggest the amount of human effort that has been set free by the manufacture of power. My imag-

ination is unequal to the task of giving you more than a hint of the change in man's condition which has just begun, and even to-day the manufacture of power, an art a little more than a century old, is in process of revolution. The prime mover of yesterday will not be the prime mover of to-morrow. Our methods of using the stored heat energy of the sun to-day will be history 25 years from now.

It is less than 150 years, since Watt made the reciprocating steam engine a thing of actual use, and fairly began the era of manufactured power. Already the reciprocating steam engine is doomed, except for certain special uses. The development of the transmission of power by electricity has made it possible to use the high efficiency of the steam turbine, and the use of turbo-generators is even now large and spreading fast. But the turbine is only a step. Its successor is already foreshadowed in the gas engine, burning producer gas. Side by side with these changes in the type of prime mover advances the art of transmitting and using power by electricity and so swiftly does the art advance that now the day seems close at hand when we may see short but important lines of steam railroad of heavy traffic converted to electric working. The power houses will be equipped with steam turbines or with gas engines burning producer gas. Alternating current will be sent out over long transmission lines and stepped down and used in the car motors without converting. Two great things will be accomplished. Working cost will be reduced and the public will have more frequent, cheaper and perhaps swifter service.

These are a few of the great engineering changes now visible over the horizon. If we had time we might speak of others in the fields of transportation, of sanitation and of manufacture, which will possibly have even more effect on the wealth and happiness of man than those which I have mentioned. For instance who can foresee the effect of countless small improvements in manufacture which are flowing from the swift development of mechanical, electrical and chemical knowledge and skill? And perhaps even greater results will flow from improved sanitation saving present waste of human energy. And these changes are close at hand.

We may reasonably suppose that 25 years from now, when many of the young men now sitting before me are in the full tide of their useful work, these United States will have a population of 120,000,000. That will be more than the United Kingdom and France and half of Germany combined. It will be a free and homogeneous population,

more efficiently educated than any people the world has ever seen. It will be a population of singular daring and enterprise, this for two great reasons. For ten generations the Americans have lived under conditions to develop courage and enterprise ; and the immigrants coming to our shores must be, generally speaking, class for class, more courageous and enterprising than those whom they have left behind or they would not have come. This population, so vast in numbers, so highly educated, so courageous and enterprising and so free to work, each man in his own way, will be seated in a temperate climate, amongst unrivalled resources of soil and mine, in a country intersected by great natural waterways and covered with a net work of railroads and with a vast coast line on the two great oceans. Put into the hands of such a people, so situated, the means for the manufacture of power and their influence on the world, physical, intellectual and moral may be greater than the influence of the men who built the Roman Empire, greater than the influence up to this time of the race which built the empires of the English-speaking people. What a glorious thing it is to be a young American at the dawn of the new epoch !

These matters of which I have just been speaking are important. They are occupying much of the best intelligence of the world. They are pursued with most admirable enthusiasm and devotion. But regarded in a broader way they are only incidents in the general forward movement of the new epoch. Not only have we entered on another ethnical period, but upon the most important period in the progress of mankind.

Perhaps you begin to wonder where I am coming out, perhaps you are already asking what all this has to do with the announced subject of my lecture—"Some Relations of the Engineer to Society."

My proposition is that the engineer more than all other men has created this new epoch and that the engineer more than all other men will guide humanity forward until we come to some other period of a different kind. On the engineer and on those who are making engineers rests a responsibility such as men have never before been called upon to face, for it is a peculiarity of this new epoch that we are conscious of it, that we know what we are doing, which was not true in either of the six preceding epochs and we have upon us the responsibility of conscious knowledge.

If we are right in the notion that the manufacture of power has brought mankind into a new ethnical period ; if we are right in the notion that the engineer is the man who beyond all other men has

created the new conditions and who must beyond all other men carry them forward in their developement, then we are face to face with certain facts of tremendous importance to two classes of our fellow citizens. First, to those who are responsible for the training of youth for their work in the world ; and, second, to those young men who have chosen engineering as their profession.

The same events and conditions which have created the new epoch have affected the plans of education, and, so far as I am qualified to judge, those who are training the young men who are to guide the human race in the next few decades are working forward in the right direction. It is obvious that our aim must always be to açquire a more complete and perfect knowledge of the forces of nature and to this end we must have mathematics. Years ago Prof. Bartlett in the introduction to one of his remarkable books, said that the man who is endowed with the priceless boon of a copious mathematics possesses the key to the external universe. It is my observation of a good many young men starting as engineers that their mathematical training is defective. Instead of holding a key they have a feeble grasp on something as vague as fog ; they have not been trained to use their mathematics as a tool for investigation, or for analysis, or for conclusive reasoning. Perhaps we may attribute this partly to the survival down to this day of Plato's notion that geometry is degraded by being applied to any purposes of vulgar utility.

Close to this is physics. A command of those facts and laws which we roughly group under the head of physics is more important than a command of mathematics. A mere mathematician cannot be an engineer, but a man can be an engineer with limited mathematics if he has a working conception of the laws of physics. My favorite test of the intellectual power of a boy is to ask how he stands in physics. A high stand there is a pretty certain indication of imagination, of power to analyze and of capacity to reason.

Command of the forces of nature requires besides mathematics and physics a specific knowledge of those branches of learning which we call the natural sciences. The relative importance of any one of these to any one man must depend upon the kind of work which he intends to do, but some knowledge of almost all of the natural sciences is important to the engineer, and a large and definite knowledge of some of them is necessary.

But mathematics and physics and the natural sciences are not the end. If an engineer is to go far he must have some of those studies

which give him broad and just and sound ideas of the relations of man to man and of man to society.

The duties of my life bring me into daily contact with large industrial and commercial interests employing many men, and I say in all sincerity, and with due regard to the meaning of my words, that it is far easier to hire engineers than it is to hire men.

It is my constant observation of four engineering works, employing about 20,000 men, that the engineers reach the limit of their usefulness from defects of character, rather than from want of technical attainments. Our greatest difficulty is to find courage, candor, imagination, large vision and high ambition. I do not know which of these qualities is most often lacking, or which is most essential. The lack of courage and candor comes most often to my notice, but the lack of imagination and of broad outlook produces the most serious disasters. All of things these an engineer must have if he is to go far, and all of these any citizen must have if he is to go far in the work of life. Our scheme of education will be radically defective if it does not provide for the development of courage and candor, of imagination and broad vision and high ambition. Our scheme of education of the engineer and the citizen must also teach our youth something of the large mistakes of men and nations in the past and something of their successes. Lacking that teaching we see the farmer in Texas and the third rate lawyer in Congress and the professional friend of mankind in Nebraska re-inventing ancient errors and diverting valuable energy from the useful purpose of hoeing corn. It is not for me, not even an amateur in education, to say how these things should be reached, but I venture a suggestion.

Scientific study may be in itself a great expander of the imagination. You will remember that Prof. Shaler wrote five dramas in blank verse to prove this. I am not competent to judge of his demonstration, but at least I venture the assertion that the study of chemistry, or of biology, of machine design, or of analytical geometry, of geology and astronomy is as quickening to the imagination as the study of Greek or Latin grammar, of moral philosophy or of rhetoric, or as a formal and routine study of English literature. The result is mostly dependent on the teacher and not on the thing taught. The quickening influence is the human influence.

This brings me to another suggestion. Gordon used to say that it would be better if the young British officers were made to read Plutarch's Lives. "There we see men of no true belief, men who are

pure pagans making their lives a sacrifice as a matter of course. In our day it is highest merit not to run away." This is a fertile suggestion under which lies a truth of the greatest importance in the scheme of education. At this moment we may see Plutarch's men fighting for their country on the other side of the world and showing noble devotion and a lofty idealism, because for centuries and centuries these ideals have been held always before them. Admiral Togo's little address to the spirits of the dead the other day in Tokio was a noble inspiration to the youth of his nation. It had the very spirit which made Plutarch's men immortal. The essential thing is to bring youth into habitual and constant contact with great men and great ideas and great deeds. Make them read Huxley's Life and Letters and Lord Robert's 41 Years in India and Grant's Memoirs. There they will find the simple foundation qualities, love of truth, courage, patience and fortitude, tenacity and devotion, working in great fields of effort. If these examples do not stir a young man, you had better let him go quietly back to hoeing corn. Huxley has said that the progress of mankind has been through the production of men of genius, but society cannot deliberately and consciously produce men of genius. They are the rare fruit of a thousand uncontrollable conditions, but we can deliberately and consciously develope leaders, and the affairs of men have never called for leaders so loudly as now.

I said a while ago that we were face to face with facts of tremendous importance to those who are training young men for engineering, and to those who have chosen engineering as their profession. I have suggested a few considerations, more particularly for those who are educating the young engineer and now let us turn to the engineer himself.

It is my proposition that the engineer more than any other man has brought about the new epoch which we have now entered upon and that he more than any other man is to lead mankind forward in the next century or two.

But who is this engineer to whom we assign such a place in human progress? What is engineering? These claims, so broad as to seem extravagant, must rest on a broad foundation.

You will have observed that of the six great forward steps taken by the human race as a race, five were gained in enlargement of his physical powers and improvements in his material welfare, through conbuests over the forcesof nature, and the sixth of these great steps worked for his advancement by enabling him to preserve and distribute know-

ledge. Even that step probably had its greatest value in hastening the conquest of nature. So we must not be surprised to discover that progress is through knowledge of a material universe.

Some eighty years ago Tredgold made that famous definition of engineering which has never been improved upon. It is the art of directing the great sources of power in nature to the use and convenience of man. Broadly this definition must include the physicist, the chemist, the biologist, the geologist and the metallurgist for they discover those laws and properties of matter in the knowledge of which the engineer must work. Narrowly the engineer is one who, having knowledge of the laws and properties of matter, designs and constructs. The primitive engineer, the man who had that instinctive feeling for the forces of nature and for the properties of matter, and that quality of contrivance which must be born in the man if he is to be an engineer at all, taught his fellow savages to use fire, to use bows and arrows and to make pottery. Then he taught his fellow barbarians to use the strength of the larger animals and to smelt and forge iron. Just so the modern engineer using the same Heaven-sent qualities is carrying forward the conquest of nature until he has brought us into this last and greatest era, the era of the manufacture of power.

I shall not stop to name his doings, they are written across the face of the earth. You remember what Carlyle says of the English, "Of all nations the English are the stupidest in speech, the wisest in action. Thy epic, unsung in words is written in huge characters on the face of this planet,—Sea-moles, railways, fleets and cities, Indian Empires, Americas, legible throughout the solar system, England her mark." Such, too, is the epic of the engineer written in railways, canals and bridges, in fleets and harbors, in water works, roads and parks, and finally in the great ultimate struggles of mankind on the battle field to save and destroy nations. There, too, the engineer writes his tragic poetry. You never thought of him as a poet did you, and yet in the last 100 years the highest expressions of the creative imagination have been in the work of the engineer.

A few years ago Mr. Abram S. Hewitt said that Sir Henry Bessemer had done more than any other man of his time to destroy the power of the privileged classes in Great Britain. He was the great apostle of democracy. Bessemer's service to mankind was to lower the cost and increase the quantity of steel and so make possible the enormous developement of transportation in the last half of the last century which has changed the face of society, and I don't believe

Mr. Hewett over-estimated the importance of Sir Henry Bessemer's achievements. The wheat that makes a loaf of bread is carried from Dakota to New York for 1/5 of a cent. One day's wages of a mechanic will carry from Chicago to Liverpool food to last him a year, quick transportation has cut the peasant loose from the soil of his little parish and opened the markets of the whole world for the labor of the artisan. All this means that improvement in transportation has been one of the powerful forces for preserving and spreading liberty. Thus Bessemer was the apostle of democracy. The engineer has made life freer and easier, he has helped to destroy arbitrary class distinctions, and also he has prolonged human life.

I shall not dwell longer on what the engineer has done. I wish especially to take a little time to point out some of the things which he is about to do. Bear in mind that in what I shall say I use the term "engineer" in its broadest sense to indicate the man of modern scientific education and of practical contrivance. Trained in daily contact with exact and inexorable laws he is becoming more and more a leader in large affairs, he is fast taking his place at the head, and close to the head of the great industrial concerns. Mind I do not say that he will displace men of other professions. Men bred to the law, men trained in business will always rise to the top. Superior men will make their way to command through many different avenues. What I do mean to say is that the education and experience of an engineer especially fit him for high administrative positions not now commonly thought of as engineering work. Carlyle tells us that "Frederick the Great's ambassadors are often soldiers. Bred soldiers, he finds, if they happen to have natural intelligence are the fittest for all kinds of work." In Frederick's time engineering as a profession did not exist. Soldiering came nearest to it, and there is great likeness in the work of the engineer and the soldier and in the qualities of mind and character developed in the two callings. Both must ascertain physical facts without mistake. Both must analyze and weigh evidence and must reason correctly. Both must deal with relations of time, space, force and matter. Both must handle men in action. Both must have the restrained and disciplined imagination to project clearly conditions and results which they cannot see. Both must decide, often very quickly, knowing that on the decision hangs success or failure. But this is the training which makes men of action,—leaders, commanders. No doubt you will agree with much that I have just said, but I question if you will quite appreciate the gravity of the sudden, emergency

work which comes in an engineer's life. Suppose you are putting down a deep foundation alongside of a twelve story building in New York City and the quicksand begins to run and the walls of the big building to crack. The peril is not so pressing as the peril of battle for you can stop work and think. But you must think straight and act right or you will cost someone a lot of money, even if you kill no one. Suppose you are putting in a foundation for a bridge pier in the bottom of the Mississippi and the river bed begins to scour and a caisson as big as a house begins to tip and to move down stream. A great deal of money depends on what you do in the next few hours. Suppose you are putting a tunnel under the St. Clair river and the compressed air begins to blow out through a sudden pocket in the river bed. Here is an affair of minutes, and of life as well as money. These very things have happened and are exactly the things that come as a matter of course in an engineer's life, and they are met by just the same qualities of courage and stored up skill and emergency judgment that you must have ready when the enemy gets on your flank. Beyond all this the engineer is of necessity a student of costs and economies. He must know what it costs to move a yard of earth and to put in a yard of concrete and why. He must know what it costs to produce a horse power. He has been defined as a man who can do well for a dollar what any man can do somehow for ten dollars. Beneath all this must lie sleepless fidelity to his trust.

These are some of the qualities of leadership, obvious, and recognized as produced in the contest with nature ; but there are others, higher ones, not so obvious. I mean the qualities of moral leadership. Probably you never thought of the engineer as a moral leader and yet I have often thought and said that in a knotty case of applied morals I would sooner trust an engineer than any other man. I once said this to that famous moralist the late speaker Reed. It was apparently a new thought with him. He reflected as much as a quarter of a minute, which was a long time for him. "Yes, "he said," I guess you are right, a minister has no sense of proportion in sin." That thought is a little too delicate and complicated for me to follow further, but the lawyer is fair game. You will remember the saying of Macaulay on this matter. " We will not at present inquire whether it be right that a man should, with a wig on his head, and a band around his neck, do for a guinea what, without those appendages, he would think it wicked and infamous to do for an empire ; whether it be right that, not merely believing but knowing a statement to be true, he

should do all that can be done by sophistry, by rhetoric, by solemn asseveration, by indignant exclamation, by gesture, by play of features, by terrifying one honest witness, by perplexing another, to cause a jury to think that statement false. It is not necessary on the present occasion to decide these questions." Nor is it necessary for us here to decide a question which every law student has debated over and again. For my present purpose it is enough to say that the daily practice of a profession concerning which such questions can arise puts a man of weak mind or weak character in very considerable peril of becoming a skilful sophist and a weak moralist. Even in the daily walks of business there is considerable temptation to obscure the truth. But the man who passes his life in contests with nature is not apt to be a sophist. The engineer can have no object in concealing the truth or in misusing it. His work is a material fact ; it is not an impression upon the minds of other men. No trick of words, no art of speech, will make his bridge stand up, or his bearings run cool, no ingenuity of argument, no power of rhetoric, will save one ounce of coal per horse-power-hour. We all know in some vague and abstract way that we must yoke our wagon to a star, but the engineer must do it. The law which guides him is not the product of the schools and the courts, it is not the product of changing standards of life and thought ; it is the eternal law of nature. So far as he finds it and follows it he succeeds ; so far as he misses it he fails, and there is no escape for him. Nature always stands watching him, neither kind nor cruel, but perfectly just ;—swift, inexorable, and inevitable–at once his guide and his judge. Who else of all mankind has a discipline so fine? Reward is so prompt, punishment is so swift and sure. Emerson has said–" The mind that is parallel with the laws of Nature will be strong with their strength."

I have pointed out some of the special and peculiar qualifications of the engineer for leadership. There is another which he enjoys in common with other professions. I mean that which we may call the professional spirit. It often seems to me that some of the great dangers to the social order which we see around us will be lessened, not cured but lessened, by the growth of the influence of the professional man in affairs. We are worried about the growth of corporate power. I don't believe that corporations are worse managed than they used to be, but they are bigger and stronger and we hear more about them, as we hear more about most things. However all that may be, we shall not change human nature by law and corporate

nature is human nature. I see much good to come from the growth of the professional spirit in corporate management. The professional spirit is in its essence the sense of trusteeship. When the professional man takes in trust the affairs of his client that trust becomes more binding upon him than his own personal interests. I am often amazed when I think of the vital force of this professional spirit of trusteeship. I am often astonished when I think of the great number of very common-place men who work along year by year with sustained devotion to a true standard of professional duty. It confirms my faith in the notion that the mass of mankind like to do their duty if they can only know what it is, and the mass of mankind desire the aprobation of noble minds. It is my impression that the true professional spirit is at least as strong amongst engineers as in any other profession, and I am often tempted to think that it is stronger. Here then we see still another reason to look forward to the leadership of the engineer.

Those of you who have been dozing or wandering while I have talked and who have caught only the high spots will have got the impression that I have been claiming the earth and the fullness thereof for a small group of our fellowmen who have chanced to band themselves in a certain profession. My real purpose has been to call attention to the commanding importance in the advancement of mankind of a certain sort of training and I had hoped that the presentation of this thought, while not at all novel or original, might have a certain interest to you gathered in the shadow of this noble university, and especially to the young men.

I have said that the engineer brought about this seventh epoch in the progress of the human race, the era of manufactured power; but I am not sure but we should go back 300 years to Lord Bacon. It was Bacon's purpose to teach man to gain command over nature and he taught that this could be only by diligently learning the truth and then following it. And this is the real significance of the engineer as an ethnical force; he must know the truth and live by it. Bacon was not the first man to observe natural facts correctly and to reason from them simply and boldly. The savage engineer who taught his fellows to make fire must have done that. But Bacon roused great numbers of men to the dignity and value of natural knowledge. And I would ask you to remember, and especially the young men, that knowledge of man and his deeds and his motives is a branch of natural knowledge. If we are to help mankind forward in this new era

on which we have entered we must gain positive knowledge, and we must vitalize it by contact with great characters and great events. We must get command of the sources of power in nature and then within ourselves, we must have courage and candor, fortitude, tenacity and imagination, and devotion ; and the greatest quality of all is devotion.

Mr. F. W. Skinner, '79, Associate Editor of *The Engineering Record*, was the next speaker. Mr. Skinner reviewed the growth and progress of the College at some length. He paid a very high tribute to the Professors and their work and expressed his sorrow at the loss of Professor Fuertes. Referring to the needs of the College he expressed the hope that it might always continue to lead among engineering schools as it had in the past, but said that if such was to be the case much earnest work must be done by the Alumni to arouse an interest and secure the necessary funds. That such an aim could be attained he had no doubt, but it required the most earnest and loyal support of all the Alumni.

MR. SKINNER'S ADDRESS.

Mr. Chairman, comrades and ladies! To those of us who return after long absences many things are new and strange, great changes have made for growth and progress and while we rejoice in the multitudes that fill the old halls and many new ones and feel the spirit of kinship for these, our younger brothers, it brings a spirit of loneliness to look in vain for remembrance or greeting where once every face was well known. So much the more then do we prize our birthright in the dear old campus, the memory echoing chimes, the well remembered faces of our classmates that join us today, and the faithful welcome from our dear professors, most of them doubly close as friends, mentors and older sons of Cornell.

The ever quickening tide of years that has borne us from these portals has brought to each toil and care and some measure of wisdom in our grand profession. We have won different measures of success and strength, but all alike have ever constantly rejoiced in our noble Alma Mater, have cherished the pride and manly spirit which is our sure heritage from her, have shared the fraternal spirit of her sons and daughters, who bring her increasing honor throughout all the land, and more and more we love her dear name, and treasure the memories and friends which she gave us in the happiest days our lives can see.

We Civil Engineers have just pride in our college, foremost of technical schools, that stands high with all members and associates of our profession in this country. Its splendid curriculum, broad policy, lofty aims, and its high and unyielding requirements—most especially the conspicious ability and devotion of its well loved professors, and the inherent Cornell spirit have earned for us a reputation which more and more as the years roll on, gives the Cornell man standing because he *is* Cornell. Strangers believe him to have the merit of manhood and sound training and he is likely to be given an opportunity to make good. The records of our college show a splendid percentage of results. Our college stands first of Civil Engineering Colleges, but it has mighty rivals, some of them are young and lusty, strong and ambitious, determined to overtake us and powerfully aided by large endowments, and abundant state appropriations which we woefully lack.

They can duplicate our curriculum, and have done so, they can copy our methods, they can excel our present laboratories and apparatus, they can win and have won our ablest alumni to teach their students. Deans, Directors and Professors in a score of other engineering colleges are Cornell men. Does all this point to a continuation of our acknowledged supremacy over other engineering colleges? It may point to that or it may point in the opposite direction. It rests with us here today and with our fellows, which way the index shall turn.

Cornell must not follow, she must lead. She must ever maintain her position well in advance of the times, she must originate not imitate. She must continue to give as of old, what none else can. She must be the standard by which other American engineering colleges shall be measured.

Many features of a broad technical education are now well perfected and are standard with all first class colleges. Some of them we originated; we have no copyright on them, we gladly see them adopted elsewhere.

For the ordinary standard engineering training we offer much what some others do, plus the personality of our instructors and the spirit, traditions and atmosphere of Cornell.

Good, let us then maintain this, creditable and efficient, and since it alone will not make us leaders, let us also aspire to a higher level, to a great school of advanced study, of higher investigation, of research work, of progress on new and important lines, where men of the highest training and greatest abilities and experience shall con-

duct study and experiment, where they shall instruct higher students and collaborate with experts and specialists and eminent engineers who may devote part or all of their time to research or instruction here, or with practicing engineers who may come here, for special preparation for proposed work. This would be indeed, a University of Universities, a postgraduate school for master engineers and worthy of Cornell. Not the least advantage of this University of Engineering would be its relations to the engineering colleges throughout the length and the breadth of this country—and abroad. Each would send its picked men, its ripest students, its most brilliant sons to receive their final instruction here, to pursue investigations and make advances in their profession such as have never before been possible and will infinitely benefit engineering, commerce, industry, and the whole nation, and the progress of humanity. Think of the scores of Cornell Alumni teaching in and directing other engineering colleges, think of their influence, their needs and their ambitions. How loyally and gladly they will serve their own students and their Alma Mater. Their highest standards and greatest successes, great achievements in their new fields will add so much to Cornell's fame ; they will rear their brightest graduates to come for final education to Cornell. Many of us too, who by life work and years of special study win sufficient eminence in our profession, may attain the honor of a call to return, at least for intervals, and impart our experience to advanced students. Or in the execution of some great work we may return and receive counsel and guidance inestimable from the world's masters.

Fellow Alumni, I believe there is no middle course. Either such a positive and glorious advance, or a retrograde. There is no standing still, even if we could, our rivals will not.

In her thirty year's career, Cornell has just accomplished the first generation. It has fulfilled and excelled its most brilliant hopes and dreams. It stands for strength, merit, advanced ideas and courage. But its founders have passed away, its benefactors grow few. It is considered fairly launched and able to battle its own way through life. But its very progress and great growth have created vast needs far more rapidly than its resources have enlarged, nay, many of its resources have suffered shrinkage while its necessities have multiplied. We have no fairy godmother to provide for us, the lusty young fellow must look out for himself ; the only thing he is certain of is what he does himself, most of us have learned this truth individually, it applies equally to the University. Cornell reared us up to successful

careers, prosperity and honorable positions. Now she relies on her sons for loyal support. Every University's strength and glory is in her alumni ; let us not fail in our duty and privilege. It is true that few engineer alumni have much personal wealth, or even great leisure to bestow on Alma Mater. She does not ask it. She needs our loyalty, our constant remembrance and our influence in her behalf at all times, our faithful testimony and our watchfulness to see how, directly and indirectly, we can serve her and influence all those who possess the power to give her material aid. By giving these we can do much for the most urgent necessities of increased room for our great body of under-graduates, larger facilities for laboratory and research work, recognized college policy, relief from uncertainties and excessive burdens of its faculty and the immediate and progressive establishment of advanced departments of a high order.

All of these things may not be within our initiative, but they are within our influence and assistance and as fast as we demonstrate their value and feasibility can be made the subject of careful consideration by the faculty, the trustees and the alumni.

We can best help by concerted effort, together we are powerful and enthusiasm multiplies, let us begin by forming alumni C.E. associations in every locality where even a small group can be gathered. There need be little formality, and not much labor or time expended, but working organizations with occasional stated meetings for social and professional purposes are easy and very pleasant, they require but little time, effort and money and furnish a means for concerted actions and great influence that can not be overestimated. United in one central association of local branches the benefits to individuals, the profession and the University may be vast. Let us therefore get together and keep together.

To some of the oldest of us, the campus of today, so stately and beautiful, so full of life and great interests is so changed from early days that we look almost in vain for land marks, but we do not fail to find the most precious ones—our senior professors who have given their life's works to us and to Cornell. He who for many years guided the affairs of the college through adversity and prosperity, from feebleness to splendid vigor and strength, who watched it grow and by his utmost effort promoted its prosperity has spoken his last words to us. We all remember his warm interest in his boys, his great plans and high ambitions for the college ; would that he could once more counsel and inspire us. He devoted his life unreservedly to the college, his

loyalty and zeal were boundless. All of us revere and love his memory, let us strive as individuals and engineers to be worthy not only as pupils but as friends of Director Fuertes.

Almost the oldest alumnus and the most recent graduate are on an equality in one of the greatest and best appreciated privileges of a Cornell Engineer—they have been taught by and possessed the friendship of Professors Crandall and Church. Elder Brothers both, of all Cornell engineers they stand unapproached in the excellence of their life work and unapproachable in the love and appreciation of their students. As we grow older we may breathe pensive sighs of relief for the immunity which distance lends to certain mathematical and mechanical pastimes that they revel in, but what little accomplishments we do still possess in those directions we owe to the two oldest teachers that ever labored, all too patiently, with our undergraduates. Every Cornell student or graduate who was ever discouraged, sick or in trouble, who needed encouragement, assistance or counsel received it in abundance from them. The warmest place in our hearts, our love and respect is given without measure to them, now and always.

The Civil Engineering College of today and all its recent great classes owe also more than can be repaid to the other members of our loyal, devoted faculty; highly trained and most efficient, their success has kept pace with their loyalty and they, too, have secured results far beyond the facilities accorded them.

Especially have we occasion to appreciate our splendid course in bridge and structural work. It is second to none in existence and has been so ably planned, systematized and developed by Professor H. S. Jacoby that many bridge engineers and specialists would gladly profit by its advantages.

Let the pleasures of today's reunion determine us to come back more often in the future to the old campus where we can meet old comrades and bring our sons, and let us never be indifferent to our duties to Alma Mater, to our noble profession and to each other.

Mr. Skinner was followed by Mr. J. H. Edwards, '88, Assistant Chief Engineer of The American Bridge Co. Mr. Edwards had left his professional affairs in New York and entertained the audience with reminiscences of college life, and remarks upon its various phases. He thought speech-making, though not essential to an engineer's professional work, was nevertheless a valuable accomplishment and should not be wholly neglected. His address was the last on the programme and as the meeting arose to adjourn, a silent salute was given

to the memory of him, who for more than a quarter of a century, had guided the affairs of the College and under whom a great majority of the Alumni had received their degrees, Professor Estevan A. Fuertes.

In the afternoon, luncheon was served in the gymnasium and having freed their minds from weighty subjects, the engineers gave up their time to the consideration of things to eat and of college days. Mr. Willard Beahan, '78, Trustee of the University, was toastmaster, and he guided the feast with a master hand.

Toasts were responded to by Professors Crandall, Church and Jacoby, and Messrs. Borden, '78, Ostrom, '77, Thompson, '05, and Trautwine, '00. The Professors were greeted with much applause and the friendship and good feeling manifested could not fail to smooth out a few wrinkles and make one's next year's work seem easier.

Mr. Borden seemed to have had the largest amount of fun in his college days but showed no hesitation about sharing it with others.

Mr. Ostrom, the John Paul Jones of the Cornell Navy, told how he did it, and filled more than one heart with envy when he spoke of receiving the crown of laurels on the steps of Sage.

There were college yells and songs galore. The Glee Club rendered numerous selections and kept the chorus well sustained. The greatest enthusiasm was aroused by the presentation to the engineers of the Dean's Cup for intercollegiate games. The cup is contributed by the Deans of the several Cornell colleges to be contested for by the college ball teams, it going to the champion of a series of games extending throughout the year. In this first year of the competition, the Civil Engineers were winners.

Dean Crane made the presentation speech in his characteristic style and was cheered again and again.

That the meeting was a most joyous occasion was unanimously agreed and many expressed the hope that it might be repeated. The presence of the ladies and the Faculty, both morning and afternoon, added much to the pleasures of the occasion and in view of the graduation of the first engineer from Sage College, was peculiarly appropriate.

The especial thanks of the Alumni for planning the meeting and arranging its details are due to Professor Crandall, Mr. Gutsell, and W. S. FitzRandolph, C.E. '05. Mr. FitzRandolph was chairman of the committee. Mr. Gutsell attended to the details of unveiling the tablet and Professor Crandall aroused our interest and secured the attendance.

In response to a circular to the Alumni, 93% of the replies received were in favor of the meeting. That there was not a larger attendance, is due principally to the fact that in the summer, engineers are too busy to make long pleasure trips. Many of the graduates who were thus situated have said that they would gladly attend such a meeting in the winter time. On this occasion, the matter was not taken up early enough in the year to prepare for a meeting before spring opened but the situation is now so well understood that future meetings should be planned in the winter.

REQUISITES OF A CIVIL ENGINEER.

GEN. WM. SOOY SMITH,

Consulting Engineer, Chicago, Ill.

Gentlemen of the Faculty, and Students of Engineering of Cornell University:

I feel honored by the invitation to address you this evening and only regret that I do not feel better able to do so with profit to you and some satisfaction to myself.

You are to be congratulated for the exceptional advantages which you enjoy in this great University, and I scarcely need to exhort you to improve them to the very best of your ability. You doubtless hear enough as to the great advantages of the thorough education you receive and the assistance which the prestige of Cornell, now so widely and so well known, will give you in getting desirable positions when you go forth to commence the practice of your profession.

It is my pleasant duty to give you a peep beyond by giving you, as well as I can, some idea of the requisites of a good civil engineer.

During the last quarter or half a century the field of civil engineering has become so extensive as to greatly increase the number of these requisites.

Indeed, they are so many and so varied as to make it necessary for the engineer to specialize and devote himself to some one or more of its departments,—only so many as he can thoroughly master.

And we can here refer only to the principal ones, some of which can again be sub-divided in several parts, viz:

1st. Brains.
2nd. Physical strength.
3rd. Integrity and high sense of duty.
4th. Education.
5th. Experience.
6th. Energy and industry.
7th. Tact.

BRAINS.

Not quantity of brains only, but also quality. It is doubtful whether Demosthenes, Bacon or Daniel Webster would any one of them have made a good civil engineer.

The engineer requires a good mathematical and analytical mind to enable him to pick to pieces observed facts and effects and to trace

them to their causes. And a thorough knowledge of mathematics is necessary as a preparation for the mastery of mechanics which every student of civil engineering must have ; and for the calculation of strains and determining the shapes and sizes of all parts of structures to sustain them.

A synthetical ability is also in demand for grouping the data and drawing correct conclusions from all the premises.

And, my young friends, you cannot be held responsible for the brains you have or have not. But you are accountable for the use you make of them. And going a little further back, it is incumbent upon you and your advisers to ascertain whether you have the quantity and quality of brains and other gifts you will need for success in the profession of civil engineering, before you adopt it as a calling in life and undertake to get the education it requires.

Inventive genius and the ability to make original discoveries and improvements, while not indispensable, are invaluable to the civil engineer and necessary to the attainment of the very highest rank in the profession. Not essential as there are many prominent engineers who have added little or nothing either to the science or the art of civil engineering.

PHYSICAL STRENGTH.

In getting the data necessary for designing engineering works and in superintending their construction there is very often heavy demand upon the engineer's physical strength and endurance. He must himself conduct the surveys and examinations required to develop all the facts and conditions connected with proposed works. And in many cases,—such as the reconnaisances and preliminary surveys of railways through rugged, mountainous and uninhabited countries and in the location and construction of such lines the engineers have to undergo a great deal of toil, privation and exposure. And in the direction of works of great magnitude and peculiar difficulties with which foremen and superintendents of works are not able to contend, and which require to be carried on continuously through day and night, and Sundays, the engineers must be in constant attendance to give them the necessary instructions and assistance. The great bridges spanning our mighty rivers and the tunnels passing under them and the mountains are some of the works of this class. The presence of a competent, strong-bodied engineer who will share the hardship and dangers of such undertakings gives to the foremen and

workmen the greatest encouragement, and goes far to secure on their part such energetic prosecution of the work as may be necessary to its successful accomplishment. And so to the engineer it is a peculiar requisite that he shall have "a sound mind in a sound body."

INTEGRITY.

A good engineer engaged in planning and executing important works occupies a judicial position and one of trust and it is therefore absolutely necessary that he shall be a man of high character and of unquestionable integrity, in order that he may not impair or sacrifice the large interests entrusted to him by his employers through his ignorance or venality. He must be above all suspicion of dishonesty or yielding to the temptations which dishonest men may present to swerve him from the fearless discharge of his duties for their advantage. He must also be thoroughly honest with himself and free from pet notions that may lead him into ruinous mistakes in his plans or in the execution of them and ready at any moment to abandon an idea as soon as his own conscientious study or the suggestion of another may make the error apparent.

He is far more interested than any one else can be to discover such threatened mistakes in time to avoid making them. Fair and broad mindedness and careful and many sided study and investigation are the surest safe guards for correctness in the designs and work of the engineer, and the surest means of winning that success which will command the confidence of owners and the public at large and bring reputation, patronage and opportunities.

EDUCATION.

With regard to the education required by the civil engineer you have perhaps heard quite enough, and you must realize that it is worth working hard for, or you would not be here students of Cornell.

The essential quality of an engineering education is thoroughness. As a student get the best knowledge you can of engineering and the natural sciences with which it is interwoven.

But a certain breadth is also very desirable. You should be able to write correct English and to speak it fluently. In acquiring such literary education as will enable you to do this, you will get mental discipline and a desire for general information, all of which will aid in rounding out your minds and giving them symmetrical development.

You need to be educated not only as engineers but as men.

Do not permit yourselves to be hurried too much in getting your education. Take time enough to cover the whole ground if you can. Plow deep and plant and cultivate well, the season will still be long enough and the harvest will be all the more abundant.

EXPERIENCE.

If you have done your very best in the way of education and preparation and go forth to put in practice what you have learned, do not consider yourselves finished engineers. I beseech you, do not get the "swell head."

What you learn here you must be able to use to the best advantage hereafter. Doubtless your instruction is made practical as far as it can be in a first class technological institution. But there will remain a lot to be learned from actual experience. Your education is but a tool. A woodman must be able to wield his axe to fell the forest, and this he learns to do by chopping. The rifleman must get skill and accuracy of aim in the use of his weapon by target practice before he can become a dead shot.

A mere book scholar can be but half an engineer; and a workman's skill and experience may fit him to be a most valuable foreman or superintendent of work but not a good civil engineer.

He must have such accurate knowledge of the strength, durability and other characteristics of the various materials which enter into engineering structures that he can use each of them judiciously, and this knowledge is best obtained by actual use and close observation of their behavior under the conditions and circumstances which will surround them in the structures in which they are to be employed. It is also necessary that he shall be familiar with the prices of these materials in the finished work in order to make correct estimates of cost and to select those which will prove most economical, due regard being had at the same time to their strength, durability and safety. Some of the dangers which threaten bridges and buildings, especially those in which iron and steel enter largely are very subtle and as yet not well understood; for instance, that which is called "fatigue" of these metals, which is a term concealing our ignorance rather than revealing a practical remedy.

An engineer should be a good business man as well as designer and builder, and he cannot be competent and reliable as such in a business requiring the use of costly materials in great quantities, the market

prices of which he does not know but can best learn by observation, inquiry and experience in purchasing them. Experience in dealing with contractors gives him acquaintance with them and their methods that enables him to deal justly with them and at the same time to guard carefully the interests of the owners. Any collusion with contractors on the part of the engineer should be, if it is not, a penitentiary offense punishable by long confinement at hard labor.

Now supposing an engineer has plenty of brains of the right sort—a strong and healthy body—a right character—education and experience, there will still remain an indefinable something—call it luck,—tact, or what you will—which may exert a more powerful influence in shaping his career than any one or perhaps all of these can.

For there are first rate engineers possessing all these requisites who, for lack of this magical faculty, go through life with little opportunity to do the work for which they are so well prepared. Sometimes a young man's social or family relations are such as to open the doors wide for him to enter at once into profitable and promising employment as an engineer with the best chances for promotion if he proves worthy of it, and so his success is assured.

Again, some small and accidental circumstances may furnish the capable but retiring engineer with employment that will reveal his ability and bring him into such notice that his services will henceforward be sought for. This is his good luck.

But there is a certain self confidence and assurance, without vanity, that perhaps more than anything else enables a young man possessing it to inspire others with such belief in his ability and fitness that his application for employment will be more readily granted.

The most trying period in the life of an engineer is apt to be when, having finished his course as a student, he goes out into the world to get a suitable position in which to put in practice what he has labored long and faithfully to learn.

But let him not be discouraged. If he is not too particular as to what he is willing to do and will take any honorable employment of an engineering character that offers, he will soon get to work, and when at work he will find it much easier to make a change if this is desirable than he did to get a start in the beginning.

I will now venture to give you some of my own experience hoping that the information to be drawn from it may help and encourage you.

I left my home in a small village in Ohio when I was fourteen years of age, with twenty-five cents in my pocket, and went to Athens the

seat of the Ohio University, and worked my way through it without any pecuniary assistance, graduating in my nineteenth year.

I was a janitor at the college and had charge of its three large buildings and a campus of ten acres beautifully improved with graveled walks and fine trees and shrubbery. I swept the recitation rooms and halls of the buildings and kept the walks in order ; carried hundreds of tons of coal up three pairs of stairs and the ashes down again ; made the fires in the recitation rooms and so earned my boarding, clothing, books, room rent and tuition and got the highly prized title of "Professor of Dust and Ashes". I worked hard during vacations and had fifty dollars at the end of my course over and above all expenses. By the labor that I performed I got such physical strength and development that I have been remabkably healthy and strong, capable of great endurance without painful fatigue during sixty years of extraordinarily active and arduous life.

On graduating at the Ohio University I got an appointment as a cadet at the U. S. Military Academy at West Point and graduated there in my twenty-third year. Went into the regular army and finding the life of an army officer in time of peace too idle and unpromising resigned at the end of a year and soon ofterward took up civil engineering. And ever since, with the exception of three years and three months of very hard military service at the front during the War of the Rebellion and about two years of foreign travel, I have devoted my time and best energies to difficult engineering work covering a period of more than fifty years, and embracing seven bridges across the Missouri River, —two across the Ohio,—two across the Mississippi and one each over the Savannah, the Schuylkill, the Platte and the Susquehanna Rivers. Some of these I designed and built wholly or in part as chief engineer and some as contractor.

The first great work I had in charge was the construction of the piers of the bridge of the Charleston and Savannah Railroad across the Savannah River, sixteen miles above the city. These piers consisted of cast iron cylinders six feet in diameter sunk by the pneumatic process through about thirty feet of sand to hard bottom. This was one of the first works done by that process, and I had but little knowledge of it. I soon found that the plant employed was crude and poorly adapted to its purposes. The air-lock was too small and of equal diameter with that of the cylinders so that when in place it cut off all natural light from the interior of the cylinder and artificial light had to be provided. Sperm candles were used and these burned in the compressed air with

a dense black smoke which almost choked the workmen. The air-lock was but four feet high and its capacity was so small that it would hold but a small quantity of the materials brought up into it from the bottom in bags by a hand windlass, and it had to be emptied at short intervals. This so interrupted the work of excavation that it made it slow and tedious, and the men working in the air-lock stood bent in painful positions. It required two weeks of constant labor day and night to sink a cylinder to a depth of thirty to forty feet. I designed an air-lock with a chamber six feet high and a diameter eighteen inches less than that of the cylinder, with a heavy cast iron bottom six feet in diameter to fit the top of the cylinder; and to permit the material to be discharged as fast as it was raised into the lock, two chutes were passed through the shell of the chamber like the sleeves of a shirt and at such an angle as would cause the sand to slip down through them to the outside. These chutes were provided with a valve at each end through which they could be filled from within and discharged without. But one man was required in the lock to operate it and he could stand erect.

Natural light was admitted during the day time through bullseyes of glass set in the offset that was like the rim of a hat nine inches in width at the bottom of the lock, and at night the light of lamps was supplied through the bullseyes in the same way. With this improved air-lock permitting the excavation to go on continuously the time required to sink a cylinder was reduced from two weeks to four days. Later on we reached a bed of sand so compact that the air pressure required to force the water out at the bottom was so great that we feared it might lift the cylinder. To avoid this danger a four inch pipe was carried up from the bottom and out through the air-lock and the water forced up through this pipe and discharged, the pipe being provided with a cock that could be operated inside the cylinder by which it could be opened to permit the water to flow out and closed to prevent the escape of air when the water had been discharged.

While I was, myself, engaged in the management of the pipe it happened that it penetrated a few inches into the sand and when the water was all discharged a current of air rushed through the pipe carrying a large quantity of sand with it in a constant stream. A telescopic section of a little larger pipe was at once procured and slipped up over the smaller one at the bottom and the circular opening between the two pipes was closed air tight with a hemp packing. The cock was then opened and the telescopic section of pipe slipped down into the

sand as the excavation proceeded at the rate of a cubic yard per minute. This reduced the time of making the excavation for sinking a cylinder thirty feet from four days to six hours. Most of the time was required for putting on the additional sections (nine feet long each) to lengthen the cylinder as it sunk. Before we hit upon this rapid method, one of these cylinders in sinking struck a cypress stump on one side at a depth of thirty feet below water surface and took a heavy inclination. We did everything in our power to correct this, working night and day for two weeks, putting all the strain upon it that we dared for fear of breaking it off. The valves of our air pump were of rubber and these would only stand continuous work for three or four days when the heat from friction and the compression of air was such that the rubber valves would give out and the air pressure inside the cylinder being lost the cylinder would fill with water and several feet of sand that flowed in with it. We would then put in another set of valves, which would fail before we could reach the obstruction and make any considerable progress in cutting it out. My laborers were negro slaves and poor choppers. I was, myself, a good axemen and very strong and hardy. And so we prepared to hasten the excavation all we could and when the stump was laid bare I went in and commenced chopping at two o'clock in the morning and worked with all my might the rest of the night, all the next day and night and until two o'clock A. M. the third night, making forty-eight hours in all, only coming out occasionally to get my meals and a little rest in the open air for a quarter of an hour or so. At last I succeeded and we were then able to pull the cylinder into vertical position and sink it to the required depth.

This will give you some idea of the effort an engineer may sometimes have to make and the value of the strength and endurance required to do it. And I have given you this description for that purpose.

I designed and sank the first pneumatic caisson ever used surrounding Waugoshance Light House which stands upon a reef of rock two and one-half miles from shore in the western entrance to the straights of Mackinac directly in the path of vessels passing through the straits, and so one of the most important lights on the Great Lakes. This lighthouse had been built by the U. S. Government twenty years before and stood upon a wooden crib one hundred feet square divided into compartments ten feet square except one, twenty feet at the center, in which a brick tower was built one hundred feet high resting on a concrete foundation. The compartments of the crib surrounding the

tower were filled with boulders. In the twenty years that the light house had stood the outside timbers of the crib rising ten feet above water had rotted and been broken in at places by the terrific pounding of the waves and heavy ice to which the structure was exposed and it was in imminent danger of total destruction.

An appropriation had been made and plans prepared by the Light House Board for building a wooden crib protection around it. This would have been larger and more costly than the crib work of the foundation itself and so perishable that another and still more costly protection would have been required by the end of the next twenty years.

I suggested the construction of an iron caisson surrounding the tower to be sunk well into the reef and filled with a solid masonry wall nine feet wide consisting of courses of large stone two feet thick and thoroughly drift bolted with iron bolts two inches in diameter.

This plan was adopted and carried out within the appropriation and the work will last for centuries. It took three years to complete it, 1866-67 and '68.

While we were engaged on the work during the prevalence of heavy storms the seas broke entirely over it without interrupting its progress as we were well protected by the caisson. After it was built the pneumatic caisson was at once generally adopted for the subaqueous foundation of bridges and buildings and it is now so used almost universally.

Up to the middle of the last century the great bridges across our large rivers as well as most of the small ones were built of wood. Then iron came in and soon became generally used. But in the beginning so little was known of its strength and other characteristics that our best engineers felt a painful lack of confidence in the perfect safety of their iron structures. I was Chief Engineer of one of the largest iron bridge building companies in our country and as such was sorely embarrassed by my ignorance of the iron we used.

At an annual convention of the American Society of Civil Engineers, I offered a resolution calling for the appointment of a committee of our members whose duty it should be to ask the U. S. Government to appoint a Board of Engineers consisting of two Army officers, two Navy officers and three Civil engineers to make tests of American iron and steel and to make appropriations to provide testing machinery for the purpose and to pay the expenses of the board.

The resolution was adopted enthusiastically. The Committee was appointed and parliamentary usage made me its Chairman. We suc-

ceeded in getting the appropriation and the appointment of the Board of which I became a member.

The best testing machine made up to that time and perhaps to the present was contracted for by the Board and built under its supervision,—the one now in use at the Watertown Arsenal.

The Board continued in existence for three years and made reports of its valuable tests which have been continued and reported ever since by the able and disinterested government officers in charge.

These tests developed a knowledge of iron and steel which have made apparent the admirable qualities of low carbon steel for bridge construction.

Being retained by the Chicago and Alton Railroad Company to design a bridge to carry their road across the Missouri River at Glasgow,—I designed the first great steel bridge, procured the approval of the company and built the bridge in 1878 and 1879, entirely of steel even down to the name plate.

During the Centennial Exposition at Chicago, I met the great English bridge building engineer, Mr. Barlow, and told him of the efforts I was making to get steel substituted for the iron, of which our great bridges were then being built. He was much pleased and said he was himself engaged in making the same effort in England. We discussed the matter frequently during his stay and when he was aboard ship at the dock in New York, where I had gone to see him off, and standing on the deck as the gangway was drawn in, I shouted to him, "look out, Mr. Barlow, or I will build a steel bridge in the United States before you will in England." "Oh, no," he replied "we are ahead of you in bridge building, have more money for such purposes, and I will surely beat you." I soon got the opportunity to build the Glasgow bridge of steel. Just as it was finished I received a letter from Mr. Barlow closing with "how comes on your steel bridge?" And you can imagine the proud satisfaction I felt when I wired at once "my steel bridge is doing fine. It is complete and trains are now crossing it."

Now all the great metal bridges are of steel. And its use in the construction of tall buildings (sky scrapers) immediately followed and is now general and of great advantage.

I superintended the building of eight hundred feet of the Hudson River tunnel at Christopher Street, New York, and so changed the methods of excavation and construction as to greatly reduce its cost and the time required for its completion.

I introduced pile foundations for buildings in Chicago and aided in planning that of the U. S. Post Office and Custom House building in which five thousand piles were used, driven to bed rock or hard-pan; and superintended its construction. No settlement has taken place under the enormous weight of this building nor under many of the tall and heavy structures whose pile foundations I have designed and put in. This plan of foundations is now the accepted one, and it has come to stay.

Frequently during my military service I was assigned to engineering duty, to build bridges, repair railroads and construct fortifications—always with the promise that I should be ordered to duty with my command in case it was likely to be engaged in battle.

When our army first occupied Middle Tennessee the rebel army had broken up the railroads and removed or destroyed their rolling stock. And I was placed in command of all our troops guarding these lines with orders to construct earthworks for their protection, and to make necessary repairs of the lines and organize a working force to operate them. This I did, the force employed numbering fifteen thousand men.

Having been requested to give you my experience, I have trespassed on your patience in giving you some of the principal incidents of a long and laborious career, and let me assure you that I have done so through no personal vanity or pride, but only with the hope that I may encourage you not to falter at any difficulty you may encounter in your efforts to get the education and preparation so necessary to your future success as civil engineers or in putting in practice all that you may learn in what you may have to do when you enter the field of actual work.

These difficulties are but the gymnastic exercises, mental and physical, which bring full and symmetrical development of the wide range of powers of mind and body that is required in almost all the high and honorable callings in life; and especially in that of civil engineering. They are blessings in disguise for which those who triumph over them are sure to feel thankful in after life.

The watchwords of the Christian are "watch and pray." Let yours be watch, pray and *work*, *work*, *work*—and I wish you all the success you can fairly earn.

PRACTICAL SEWERAGE.

ALBERTO F. SCHREINER, '97,

Asst. Engineer, Bureau Sewers, Long Island, N. Y.

The purpose of this paper is to describe in a general way the method of designing sewerage systems and the method of construction of sewers used in the bureau of sewers of the Borough of Queens, New York City. The Borough of Queens is one of the largest of the five boroughs which form Greater New York City and the least developed one. Following are shown the areas of the different boroughs :—

Areas—Manhattan,	19.65	square	miles
Brooklyn,	60.90	"	"
Bronx,	42.68	"	"
Queens,	127.61	"	"
Richmond,	57.19	"	"
Total,	308.11	"	"

Comparing the area of the Borough of Queens with the areas of the other boroughs and considering its population with regard to the population of the other boroughs, we see that the Borough of Queens is the least populated one, as shown by the following list :—

Population—Manhattan,	1,850,000
Bronx,	200,000
Brooklyn,	1,166,000
Richmond,	67,000
Queens,	153.000

The problem of the disposal of sewage is comparatively easy in the other four boroughs, considering the ideal conditions of the water-front. Examining the following figures,

Water-front—Manhattan,	39.9	miles
Bronx,	105.6	"
Brooklyn,	132.3	"
Richmond,	51.0	"
Queens,	116 0	"

we see that the borough of Queens is second on the list as to water-front, but certain laws passed by the State Board of Health prohibit the discharge of crude sewage into Flushing Bay, Newtown Creek and Jamaica Bay, so decreasing to an appreciable extent the available water-front which under those conditions is only 27 miles long and consequently the disposal of sewage in the borough of Queens becomes

to a certain extent a difficult problem, necessitating treatment in many cases before it can be discharged.

The development of the means of transportation taking place at present, will give to the Borough of Queens an enormous increase of population in the near future. The construction of the tunnels of the Pennsylvania railroad, connecting New Jersey and the borough of Manhattan with the borough of Queens ; the so-called Belmont tunnels; the Blackwell Island bridge ; the connecting railway, and other such projects, under construction and shortly to be constructed, will certainly bring a tremendous influx of population to the borough of Queens.

Before the borough of Queens became a part of the city of New York in 1898, it was nothing else than a conglomerate of small detached villages, hamlets, and settlements. At present, the borough is divided into five wards ; the first ward, or Long Island City, containing such settlements or villages as Hunters' Point, Blissville, Dutch Kills, Ravenswood, Steinway, and Astoria. The second ward, of former town of Newtown, including such places as Ridgewood, Maspeth, Elmhurst, Corona, and others. The third ward, formerly the town of Flushing, containing the villages of Flushing, College Point, Whitestone, and Bayside. The fourth ward, formerly the town of Jamaica, containing Jamaica, Richmond Hill, etc. And lastly, the fifth ward, called the Rockaways, composed of Far Rockaway, Edgemere, and Rockaway Beach.

Before consolidation, only a few localities were sewered. Some of the existing sewage systems are at present inefficient and will have to be replaced in the near future by systems of better capacity to care for new conditions, due to the rapid growth of the borough. Some systems covering considerable areas have been worked out in the Bureau of Sewers of the Borough of Queens. Due to the pressing needs of some sections it was necessary to design such systems in the shortest possible time so as to give relief to those localities speedily. Only part of the Borough of Queens had been surveyed and mapped before consolidation ; street systems and established grades had only been worked out for a very small area of the borough. Since consolidation, the Topographical Bureau has been hard at work to survey some sections of the borough, to design the respective street systems, and to establish the proper street grades. After such map has been prepared and approved by the proper authorities, the Bureau of Sewers receives a copy of the same and the first work done is to draw a copy at the scale of 200 feet to an inch. The established grades are written

in red ink; in the corners of the city blocks, and the area of the sewer system is determined by means of the established elevations. The extension of the area depends on the lines followed by the highest elevations surrounding this area. Those lines are shown in blue, by dash and two dots. After determining the area, the position of the outlet is located, considering certain conditions. If there is a popular bathing beach in the neighborhood, such an outlet will certainly be a nuisance and proper studies have to be made to see if a better location could be found. The question of proper depth of water is also to be considered. Also if a treatment of the sewage has to be resorted to. After determining the point of outlet, the line of the trunk sewer is located; this line naturally depends on the neighboring topography, cost of construction, width of highways, and other factors. After determining the line of the trunk sewers, the main laterals are located and by means of those the sub-areas. The whole system is now clear enough to admit of locating in a very rapid way all the sub-laterals and so completing the location of all the sewers in the system.

The next step is to locate the receiving basins, which are generally placed at street corners, except when there is a depression in grade between the ends of a block. A maximum run of twelve hundred feet is allowed for one basin. A table of areas in acres is prepared, in which the first vertical and the lowest horizontal column represent feet; from twenty-five to twenty-five feet and the intersections show the respective areas in acres. Another table shows the quantity of runoff by acres or fractions thereof. Each borough of New York City uses at present different formulae, data, and methods of computing run-offs. It is not the purpose of this paper to discuss the formula of run-off which should be used. (See Mr. W. C. Parmley's paper on the Walworth Sewer, Cleveland, Ohio, in the August proceeding of 1905, of the American Society of Civil Engineers; H. N. Ogden's Sewer Design; A. P. Folwell on Sewerage). After the quantities of run-off of each sub-area are computed and the quantities to be carried by each sewer at different points are determined, these quantities are written on the map at their respective locations with a green pencil.

The next proceeding is that of plotting pencil profiles of all the street-grades along the different sewer lines, using a two-hundred horizontal and a twenty vertical scale. On these profiles the sewers can be located in regard to the elevations, paying attention to the fact that the house connection should be, whenever possible, about eleven to twelve feet below the surface of the street so as to allow proper drainage for the

cellars. Having determined the elevations of the sewers and knowing the distances, the grades are easily found by use of a slide-rule ; and knowing the quantity the sewer has to carry, by the use of Flynn's Tables, the size of the sewer is easily found. Attention has to be given to maximum and minimum velocities : if the velocity in a sewer is excessive, proper provision has to be made for drop manholes, cascades and such arrangements, if necessary. If the velocity is too small, the material carried in suspension by the water will be deposited and not only decrease the carrying capacity of the sewer but may also be the cause of heavy expenses for the purpose of removing such material. Generally after a few trials the proper depth and grade of a sewer will be found, considering the cost of construction due to deep excavation.

The last step is to enter on the map the sizes of the sewers in feet and inches and the invert elevations in feet and tenths. The brick or concrete sewers are shown by red lines ; the pipe sewers by brown lines ; existing sewers by black lines ; the invert elevations by blue figures and the receiving basins by small red circles at the street corners. The map is now ready for the tracer, who gives the finishing touches, as title, border, explanatory remarks, and proper space for the signatures of the city officials. This map is approved by the proper officials of the borough of Queens and then submitted to the board of estimate and apportionment of the city of New York. After the approval of this board, the map becomes official.

CONSTRUCTION.

When the taxpayers of a certain locality wish to have a sewer built, they submit a petition to the local board, composed of the borough president and the aldermen of the respective district. After passing the local board, the petition is sent to the Bureau of Sewers for a report in which the quantities, the estimated cost, and the assessed valuation of the area to be drained have to be indicated. The quantities, in regard to length and size of sewers, as also the receiving basins, are readily taken from the sewerage map. The number of manholes to be used depends upon the sizes of sewers ; if pipe sewers, the manholes are spaced about one hundred and thirty-five feet, to permit the cleaning of the sewers, using extension shovels and other apparatus designed for this purpose. For sewers 2′ 6″ and over, this spacing is increased to about two hundred and fifty feet. These distances may vary according to locations of junctions, curves, or other circumstances. The

quantities of extras to be used, as—concrete, broken stone, timber for sheet-piling and bracing, timber for foundation, piles, structural steel, etc., vary with geological and other conditions and it is only after some experience that the estimating engineer can decide upon the quantities to be used.

In estimating the cost, it produces a very bad impression if the engineer's estimate of cost varies to a large extent from the bids submitted. The method lately followed in the Bureau of Sewers in the Borough of Queens is to determine the quantity of material to be used per running foot of sewer and to determine the cost of the same, which naturally depends a great deal on present market conditions and location of the work. Next in line is the amount of excavation to be done, and the cost of the same depends upon the magnitude of the work and the consequent methods of excavating to be used; and lastly, on the geological conditions of the sub-soil. An allowance of ten per cent of the cost of excavation is made for pumping. All these items are added together and of the total an allowance is made of ten per cent for administration, five percent for unforseen expenses, and five per cent for interest and depreciation of plant. In regard to this last item, it must be remarked that the contractor receives each month a payment for work done, less thirty per cent, which amount is retained by the city, until the completion and acceptance of work. Again all the items are added and fifteen per cent considered for profit and certain allowances have to be made for removing surplus material, cleaning up the street, restoring the pavement, and taking care of water mains, existing sewers, railroad tracks, etc. The final total of all these items will give the probable cost per running foot of sewer. The cost of other items, as timber, broken stone, concrete in places not shown on the plan, etc., depends also on market conditions, location, and the amount of quantities to be used. After the proper report is written and a copy filed in the engineer's office, the original is sent to the president's office, and he in turn transmits it to the Board of Estimate and Apportionment to obtain proper authorization to execute the work. Receiving such authorization, the Bureau of Sewers is directed to prepare specifications and proper construction maps so that the work may be advertised and bids be called for.

To prepare the construction map a line of levels is run on the street on the line of the proposed sewer and a profile is plotted on a vertical scale of ten and horizontal of one hundred, showing present surface, established grade lines, elevation of the sewer, and location of man-

holes ; the plan showing location of sewer, manholes, receiving basins, and other details ; width of streets, angles of street intersections and block dimensions. Details of sewer sections, manholes, receiving basins, junctions, syphons, cleaning shafts, deep manholes, portals, outlets, foundations, etc., are drawn on a scale of two feet to an inch, and proper elevations, plans, and sections shown to make these details as clear as possible.

After the work has been advertised for ten days and bids have been received, the contract is awarded to the lowest bidder, when the real field work for construction purposes begins. The center-line of the sewer is determined from monuments or other available data, and proper grades are given to the contractor sfor excavation. The depths of the inverts of the sewers are given for about every twenty-five or fifty feet on grade boards placed across the sewer-trench or on some of the timber pieces used for bracing. These grades are checked frequently, as the grade-boards may settle from different causes. The field-book notes have to be kept clear and intelligible ; all reference points, stakes, and other data have to be kept properly recorded and described in the same. A diary is kept describing all extraordinary conditions and circumstances which may occur during construction so that in case of a litigation on the part of the city or of the contractor, the engineer may have all the data possible to account for the faithful and honest execution of his duties.

The type of foundation used, the type of special work done, due to unforeseen geological formations and other causes, depends entirely on the experience of the engineer in charge. The inspection is done by inspectors in the employ of the city, but in work of any magnitude or difficulty the engineer in charge has to give as much time as possible to personal inspection of the work. At the end of each working month the work done is measured and a payment estimate is prepared to enable the contractor to receive payment for the work executed, the city retaining thirty per cent of the amount. At the completion of the work, final measurements are taken and final examination made of the work done, drawings prepared showing the locations and length of piles, character and size of timber foundations, location of sheeting and bracing, and description of timbers used in the same, thus describing and locating all construction-work and material the contractor is entitled to payment for. The final estimate is prepared and the total cost determined, the difference between this final estimate and the estimates previously paid, will show the amount to be paid finally to

the contractor. The next work to be done is to prepare the house-connection map showing the location of all the spurs for house-connections by distances, measured from centers of manholes. Next in order is the preparation of assessment maps and lists to enable the determination of the cost of improvement to be charged to each property, lying in the district affected by the improvement.

All maps and drawings are filed on three-quarter inch round sticks in pigeon-hole map-cases ; on the ends of the sticks two numbers are printed, one giving the number of the map and the other the number of the pigeon-hole. The same numbers are printed on the maps or drawings. A card system is used for indexing purposes. The index is alphabetical, with some main divisions as for instance, the heading of "plans and profiles", which with its own alphabetical division, contains all the construction maps. Letters and reports are copied into a copying book and properly indexed. Each field-book has its own index on its last two pages and a special book serves as index for all the work contained in the different field-books.

At present there are three sewage disposal plants in use in the borough of Queens. One in Far Rockaway, with a capacity of one million gallons per day using a chemical treatment ; one chemical plant at Jamaica with a capacity of two million gallons per day and one at Elmhurst with a capacity of one million gallons per day. This last is a sedimentation and filtration plant. A fourth plant with a capacity of one million gallons per day has been proposed for the third ward using the Doughty Oxygen Process.

An interesting feature of disposal of sewage is presented in the sewerage system of the Maspeth and Ridgewood sections. The Maspeth trunk sewer is to discharge its storm-water flow into Newtown Creek ; the dry weather flow is to be intercepted and pumped through a pressure pipe from an elevation of $\pm - 6.0$ to an elevation of $+31.0$ into a gravity sewer which runs into a 16 feet trunk sewer in Brooklyn near the Queens borough line. This trunk sewer has at this point a dry weather cut-off connecting with another sewer, so carrying the dry weather flow to the East River and the storm weather is emptied into Newtown Creek. In this way the necessity of a disposal plant is dispensed with and the initial expenses greatly reduced. To give an idea of the actual cost of construction in the Borough of Queens and quantities of divers materials used, a few examples are herewith given :—

WEBSTER AVENUE SEWER.

Outlet Complete	$21,600 00	$21,600 00
785′-12′ 9″ sewer (a)	38 60	30,301 00
675′ 12′ 6″ " (b)	38 00	25 650 00
198′-12′-3″ " (c)	37 50	7,425 00
1459.5′-13′-0 " (d)	39 15	57,139 42
3157.0′-9′-9″ " (e)	25 60	80,819 20
6′-14′-0″ "	41 15	246 90
34 manholes	50 00	1,700 00
5293 2 cubic yards concrete in places not shown on plan	5 00	26,466 00
908,692 feet B. M. foundation timber	27 00	24,534 68
585.2 cubic yards of broken stone	1 00	585 20
185,505.5 lin. feet of piles, driven and cut off	18	33,407 19
800,527 ft. B M. timber for bracing and sheet piling	20 00	16,010 54
19,348.3 cu. yds. of rock excavated and removed	1 50	29,022 45
36 lin. feet 15″ pipe sewer	1 00	36 00
Total		$354,943 58

(a) Average cut 12′ deep 32′ wide. Part rock excavation.
(b) " " 7′ " 32′ " Soft mud. Tide water. Swamps.
(c) " " 15′ " 31′ " Sand.
(d) " " 17′ " 32′ " Rock excavation.
(e) Deepest cut 42′ 25′ wide at tops. Sand. Some quicksand.
Sections "a" to "d"—Twin horseshoe sections.
Section "e"—Single horseshoe section.
All brick sewers with concrete cradle and vitrified brick inverts.

JACKSON AVENUE SEWER.

2007.27′-5′-0″ circular brick sewer (a)	$ 17 50	$35,127 22
1882.79′-4′-6″ " " " (b)	17 50	32,948 83
1346.41′-4′-0″ " " " (c)	15 72	21,165 56
823.83′ 3′-9″ " " " (d)	12 06	9,935 39
1145.00′-12″ vitrified culvertpipe to connect receiving basins	1 62	1,854 90
33 receiving basins	146 00	4,818 00
1537 cubic yards rock excavated and removed	5 00	7,685 00
237,801 feet B. M. foundation timber	35 00	8,323 05
1,127,391 feet B. M. timber for bracing and sheet piling	25 00	28,124 78
230.67 lin. feet 12″ vitrified pipe sewer	2 02	465 95
536.94 " " 18″ " " " (e)	2 96	1,589 34
1340 " " 10″ sub-drain pipe	10	1 34
42 manholes	60 00	2,520 00
659.25 cubic yards concrete	12 00	7,911 00
262 cubic yards broken stone	6 00	1,572 00
Total		$164,235 02

(a) Average cut 17′ deep 9′-6″ wide.
(b) " " 20′ " 9′-0″ "
(c) " " 22′ " 8′-6″ "
(d) " " 17′ " 7′ 6″ "
(e) " " 16′ " 3′ 0″ "
Excavation mostly in sand. In some sections water was found in great quantities.
Sewers all circular with vitrified brick inverts and concrete cradles.

On account of the present high prices of brick-work this office has discarded the use of brick sewers and only reinforced concrete sewers are being designed. The pipe sewers are of vitrified salt-glazed stoneware and on some small contracts cement pipes have been used. If the sizes of the hubs and spigots of cement pipes are properly proportioned and if the pipes have been cured a sufficient length of time, they may be used to good advantage.

The design of sewerage systems, of details of sewers, and their construction is one of the most interesting branches of civil engineering. Conditions vary with each system and with each sewer. Topography, geological formation, density of population, form of treatment or discharge of the sewage, are factors which present problems of such variegated forms as to always add new interest to the work of the sewer engineer.

There is no other branch in the profession where the engineer requires such a wide scope of engineering and general scientific knowledge. Chemistry, bacteriology, meteorology and statistics, mechanics and hydraulics, geology and hygiene, are some of the branches of human knowledge which must be tools in the hand of the sewer engineer.

There is still a wide field open in original research to fill many gaps in the knowledge of sewer work. Data concerning influx of ground water into sewers built of different materials, laid in different strata, at various depths, are still very meagre and incomplete. Run-off formulae are still far from being, if not correct, at least approximately correct to warrant full confidence in their application.

There is, I may say, no engineering work which depends so much on the good judgment and common sense of the engineer, as sewer work. Its field of usefulness is continually enlarging, its efficiency growing and its beneficial effects becoming more and more apparent. Few young engineers and students select this line of work but if they knew of the variety of interesting questions involved in this branch of engineering, they certainly would enlist in the ranks of the "sewer men".

STREET EXTENSIONS IN QUEENS BOROUGH, NEW YORK CITY

ALBERT H. CHANDLER, '02.
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In planning for the future growth of New York City, the problem of correctly establishing street lines and grades in the undeveloped sections, is second only in importance to that of providing adequate transportation facilities between the different boroughs. While engineering and architectural structures, which prove unsatisfactory, can be replaced by others in a few years, a general street plan, once made and accepted, is imposed upon the city for all time. The older portion of Manhattan has suffered incalculably from want of foresight in this respect. It should be the purpose of the engineer to conserve the future in passing upon new designs.

During the earlier stages of its development, Manhattan Island was divided into distinct communities with separate street systems. In the territory south of Houston on the east and Fourteenth street on the west side, these different units were allowed to grow together without any pre-conceived plan, and in consequence the streets are narrow, crooked, and discontinuous.

The upper portion of Manhattan was adequately laid out by a commission appointed by the legislature in 1807, and composed of Gouveneur Morris, Simeon De Witt and John Rutherford. The engineer to this commission was John Randel, Jr., who made a survey of the island, and designed what is substantially the present street plan. As is well known this consists of a rectangular system with numbered streets and avenues, in which the blocks are 200 feet in width by from 600 to 800 feet in length, and the streets from 60 to 100 feet wide between property lines.

Mr. Randel's design was adopted in 1811. He was then employed to make a survey and map showing all of the old farm lines as well as the creeks, swamps, ledges, and other topographical features with reference to the newly established street system, and to monument each street intersection. In 1821 this task was completed. His maps, each measuring 24 by 36 inches, were drawn to a scale of one hundred feet to the inch, and consist of 92 sheets which are bound in four volumes and kept on file in the office of the engineer of street openings. These records are of the greatest practical value not only to the

city in re-running street lines, but also to the lawyer in tracing title to the real estate, and to the structural engineer in designing the foundations of buildings that are to be erected on filled ground. The cost of the work was $32,484.98 including an allowance of $1,000.00 for instruments.

In laying out this system, Mr. Randel chose for his base the easterly line of Fifth Avenue as far north as the Harlem river, where he offsetted to Tenth Avenue. The cross streets were monumented as far as 155th street, while Tenth Avenue was extended to the end of the island. A point at the intersection of the easterly line of Tenth avenue and the northerly line of 225th street has since been adopted as the center of co-ordinates for all New York City topographical maps. The major axis of this system bears 28° 50′ 30″ east of north, and coincides very nearly with the line of the avenue as established by Randel. Mr. Randel's results were remarkably good. Although his instrument was without lenses and had a vernier reading only to five minutes, he attained an accuracy that was generally in excess of 1 in 5000.

Since this survey was made, New York has extended far beyond its former limits, and now comprises an area fifteen times as great as the original Manhattan Island. The city as at present constituted was formed January 1, 1898 by the union of five boroughs, and consists of Manhattan, the Bronx, Brooklyn, Queens, and Richmond. While each of these communities has an independent local organization and elects a president as its executive head, all plans for public improvements are passed upon by a central body, called the "Board of Estimate and Apportionment", which in effect controls the expenditures of the entire city. The members of this Board are the Mayor, the Comptroller, and the President of the Board of Alderman, who each possess three votes, the Presidents of the Boroughs of Manhattan and Brooklyn, whose votes have a weight of two, and the remaining Borough Presidents, whose votes carry a weight of one.

The Borough of Queens, having an area of 128 square miles and a population of 160,000 souls, consists of that portion of Long Island, which is included within the City of New York, outside of the limits of Brooklyn. It contains a number of towns and villages, originally separated, but now joined together under one organization. Each of these units has its own rudimentary street system. The work of preparing plans and estimates for harmonizing, extending, and improving these street systems is vested in the Topographical Bureau, organized

under the Borough President, and dependent upon the Board of Estimate and Apportionment for its support.

The duties of the Bureau may be summarized as follows:

First. To make a topographical survey of the Borough of Queens.

Second. To prepare the designs for the street systems, to determine the grades of streets, and to make the maps for adoption and filing.

Third. To define on the ground by stones and bolts the lines of the adopted street systems.

Fourth. To make surveys, searches, technical descriptions, and maps for the law department and the commissioners of estimate and assessment, in the matter of acquiring title to avenues and streets.

Fifth. To make examinations, maps and reports on miscellaneous matters referred to it by the Borough President; including the elimination of grade crossings, recommendations for proposed parks and boulevards, the establishment of standards of measurement, the running of lines of precise levels, and the determination of tidal fluctuations.

These various surveys are hung upon a system of triangulation, which was originally started in 1870 in the Boroughs of Manhattan, and the Bronx by the Topographical Bureau, and developed at such a rate as was necessary to keep pace with the expanding street systems. In 1903 an arrangement was made whereby the United States Coast and Geodetic survey assumed the responsibility of extending this system over the rest of the city; and Mr. A. T. Mosman, Ass't. U. S. C. and G. S. was detailed to take charge of the work.

In choosing his stations Mr. Mosman, found it necessary, in many localities to utilize the towers of churches and public buildings, and the roofs of school houses. As these furnished poor foundations for the tripods of the instruments, a position theodolite could not be used for measuring angles, and in consequence the work was all done with repeaters. On the long lines a 10 inch Gambey and on the short ones a 6 inch Coast Survey repeater was used. The allowable error was 1 in 25,000, but the computations thus far completed, indicate that this will be reduced to about 1 in 40,000, when the final adjustments have been made.

The angles were measured in sets, swinging from left to right. Each set consisted of three repetitions with the telescope direct and three with the tube inverted on the main angle, and the same number on the explement, making twelve in all. Each angle and its explement were similarly measured around the horizon, which was required

to close within three seconds. After completing the cycle, the angles were measured again in a similar way, until four complete sets had been obtained. On account of the thick atmosphere of the city, heliotropes were required on many short lines, where the station would have been readily inter-visible without their use in more open country.

The site chosen for the base line was on Ocean Parkway in the Borough of Brooklyn, where a line perfectly straight and about 13,000 feet long was measured on nearly level ground. On account of trees, towers 52 feet high were erected at each end. The line was measured with tapes 150 feet long, stretched across 4″ by 4″ scantling, and supported at the centre by an intermediate stake 3″ by 2″ in which a wire nail has been set on grade. These stakes were carefully levelled twice to obtain the true grade and the height above sea level for use in the subsequent reductions. All measurements were made at night. The tape was uniformly stretched at a tension of 15 kilogrammes. Two thermometers were used, one at each end of the apparatus, and were read to tenths of a degree at each application. The base line was divided into four sections, each about 3300 feet long, which were measured in both directions, a different tape being employed each time. The chaining occupied several nights, one night being required for each section. The tapes were standardized by comparing them with three others, obtained from the Office of the Coast Survey, the lengths of which were known within one part in a million. The standardization was made at night under conditions similar to those which obtained when the measurements were made, and was repeated after the base line work had been finished.

In plumbing down from a high tripod to a monument in the ground, a vertical collimator was used. This consists of a short telescope with cross hairs, which is mounted vertically on a stand, and which carries a very delicate level. The collimator is set up over the spot occupied by the theodolite in measuring the angles, so that the observer can look down the tube and fix a point on a bolt or stone directly beneath.

This instrument is designed in such a way that the telescope can be revolved about its vertical axis; and in establishing a point on a monument, several sets of observations are made, each consisting of two sights. After the first sight has been taken, the tube is revolved 180° in order to be in position for the second. This method has been found to give accurate results in practice, and as the collimator can be utilized

Type of Scaffold and Signal used in the Primary Triangulation Work of New York City.

Vertical Collimator used by the U. S. C. & G. S. in the Primary Triangulation of New York City, for plumbing down from a high tripod to a monument in the ground.

for plumbing when the atmosphere is unsuitable for angle measurements, it has proved to be economical as well.

While the work of triangulating the city has been in progress, with the object of establishing the co-ordinates of permanent points from one to two miles apart, the Topographical Bureau has also been engaged in making the detailed surveys, required for the design of new street systems.

In making these surveys transit parties are first sent out to run closed traverses, tying in to triangulation points where practicable, and setting monuments about 1000 feet apart for the use of other corps who are to follow. These parties are composed of six men, who are appointed from lists furnished by the Civil Service Commission and are in charge of an Assistant Engineer. The chaining is done with a 100 foot spring balance catenary tape, the length of which is adjusted in accordance with the temperature, and the constant determined from time to time by comparison with a standard. Distances are measured in both directions and are averaged to obtain the mean. The angles and their explements are repeated six times with telescope direct and the same number of times with the tube inverted, making twenty-four repetitions in all. In case of a traverse intersection the horizon is closed. The accuracy attained is 1 in 50,000.

The transit parties are followed by the location corps. In the settled portions of the borough, where existing street lines can not readily be changed without involving the city in expensive damage proceedings, these parties are provided with a transit and tape. The organiization is similar to that of the base line parties, with an assistant engineer or transitman in charge. Traverses tied to points previously established, are run and are required to close with an error not exceeding 1 in 10,000, which is about as close as can be plotted on the office maps, using a scale of 80 feet to the inch. In making locations, pluses are taken along the traverse lines, and right angled offsets measured to property line monuments, stakes, and fences, and recorded to the nearest hundredth. Isolated houses are similarly located, where the dwellings are scattered ; and the general lines of the frontages, where the buildings are contiguous.

After making locations, the party proceeds to run levels over the area traversed. In the flat portions of the borough, where five foot contours cannot readily be traced, elevations are taken on 100 foot squares. The usual procedure is to run a series of parallel lines about

700 feet apart, along which temporary points are established at intervals of 100 feet by chaining. At each point a right angle is turned by means of an optical square, and rod readings are taken at distances of 100, 200, and 300 feet from these points on both sides of the lines, the intervals being paced or measured with a metallic tape. Cross sections are also taken where the lines intersect highways and railroad embankments.

The plane table is utilized in taking topography over rugged and wooded country. Plane table parties are furnished with sheets measuring 2′ 3″ wide by about 12′ long. By means of rollers at each end of the table, these can be made of any desired length, but it has been found most convenient to employ strips of such a size that they will contain an area 10,000 feet long by 2,000 feet wide, when plotted to a scale of 80 feet to the inch. These sheets are divided into 500 foot squares in accordance with Randel's system of co-ordinates, with origin at Tenth avenue and 225th street on Manhattan Island. Traverse points as established by the transit parties are then plotted, together with their references, and the sheets are ready to be sent into the field.

As soon as a sheet is received by a party chief, he establishes stations on commanding points from 600 to 800 feet apart, and connects them by means of a preliminary traverse. These points are then plotted by co-ordinates and are connected by lines drawn with ink of a different color from that which was originally used in the office. Important locations such as monuments and property corners are often picked up while running these lines ; but in general locations are made with the alidade and plotted in the field. Contours are drawn at five foot intervals. In order to determine directly the position of contour points at any elevation above or below the table, a wye level is used in connection with a rod on which the target has been set at the proper reading. As soon as the leveler has found a contour point on the ground, the man in charge of the plane table transfers it to his sheet by means of the alidade. Turning points are taken and the level moved ahead, whenever the territory within its range has been covered. The table is oriented from at least two traverse points, and the work is further checked by locating objects from two different set ups. On the rough ground where this method of taking topography is employed, the parties average from 30 to 40 acres a week ; and the cost, including the location of property lines and buildings is about $3.00 an acre.

In addition to such locations as are obtained in the field, village maps and the records of the tax office are used to supplement and

check the work of the parties in plotting the original street and property lines. A great deal of information is also obtained from engineers in private practice, and from the owners of real estate, who have laid out subdivisions which they desire to have incorporated into the city map.

After all available information has been plotted and checked and a sufficient area has been mapped, the engineer in charge of the bureau is in a position to undertake the design of a street system. Every such design is based upon conditions which vary according to the locality. The Borough of Queens contains a number of towns and villages which are so far developed that no radical changes can be made in their street plans without prohibitive expense. These are separated by rural communities in which the local conditions can be disregarded to a certain extent, although the main arteries of travel must be preserved. Under the present law governing street opening proceedings, the title acquired by the city is that of "a fee in trust for street purposes", and in paying for such property the whole fee value of the land is allowed. Where lots are cut up into irregular shapes, the owner also receives an additional sum to reimburse him for the decreased value of that portion which remains, and where buildings project upon the street, a further compensation is granted to cover the damage and the cost of removal. As these sums together with the legal expenses often combine to make a very respectable total, it is incumbent upon the bureau to weigh the cost against the value of every improvement, before attempting to alter the original plan. Another element of considerable importance is the sentiment of the public, who generally oppose any change which involves the removal of their homes. This opposition frequently manifests itself in the form of pressure, which is brought to bear upon the elective officials, who pass upon the completed plans, and in some instances has even effected a reconsideration of the design, after the plans had been adopted.

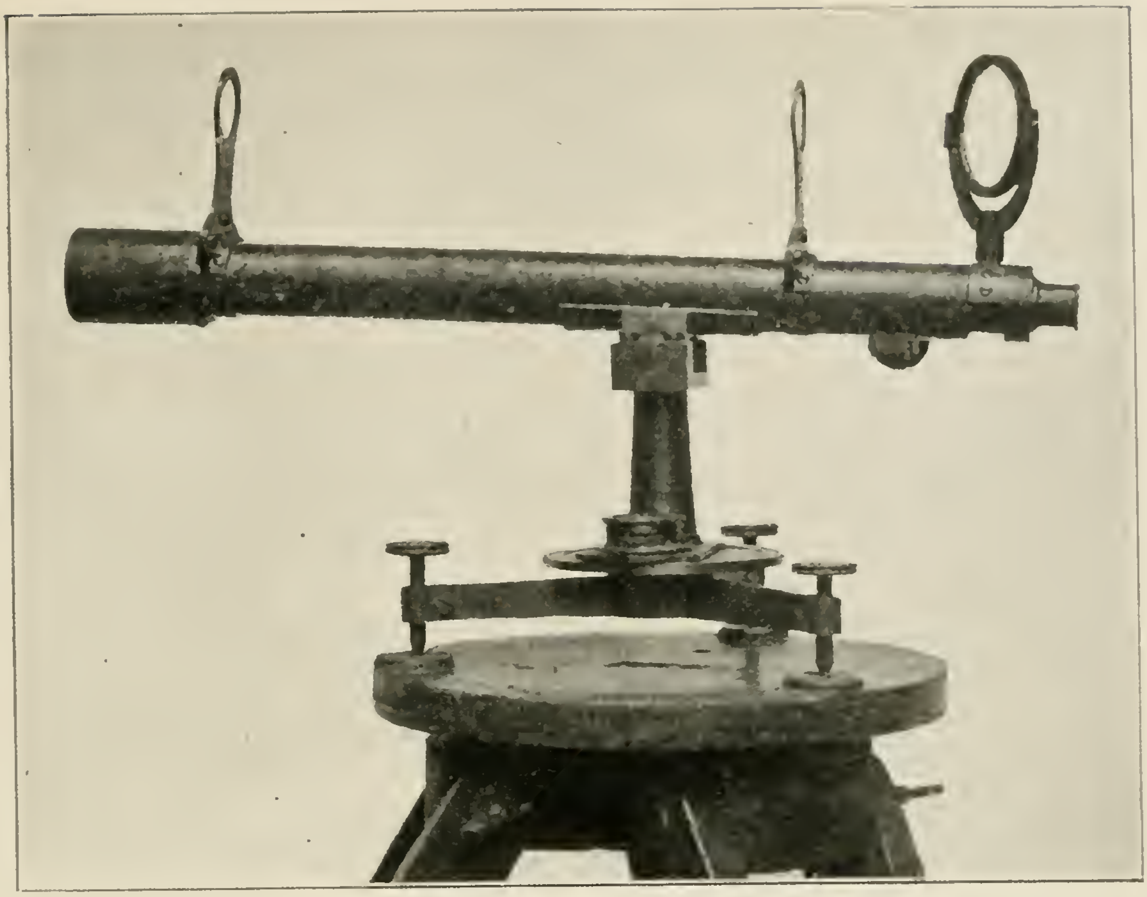
Subject to these conditions the method which is followed in working out a design is to lay down a number of arterial streets between the former villages, and to fill in the intervening area with a rectangular system, which resembles that of the upper portion of Manhattan Island in that the blocks are 200 feet in width by from 600 to 800 feet in length, and the streets from 60 to 100 feet wide between property lines. In fixing the main arteries the bureau utilizes as far as possible the old established roads, straightening and widening them when necessary, but endeavoring to do so without cutting up the abutting

lots into irregular shapes. Within the settled portions of the borough, the original lines are in general retained, although in the case of narrow and crooked streets, an attempt is always made to improve the conditions. Where the expense is warranted as for example in creating an approach to the Blackwell's Island bridge over the East river, the streets are cut through without regard to existing structures. In general terms the design may be described as a modification of that which has proved successful in Manhattan, in that the main arteries, instead of being parallel, are divergent, while the system itself is not continuous, but is broken up into sections of varying size in order to harmonize with the local conditions.

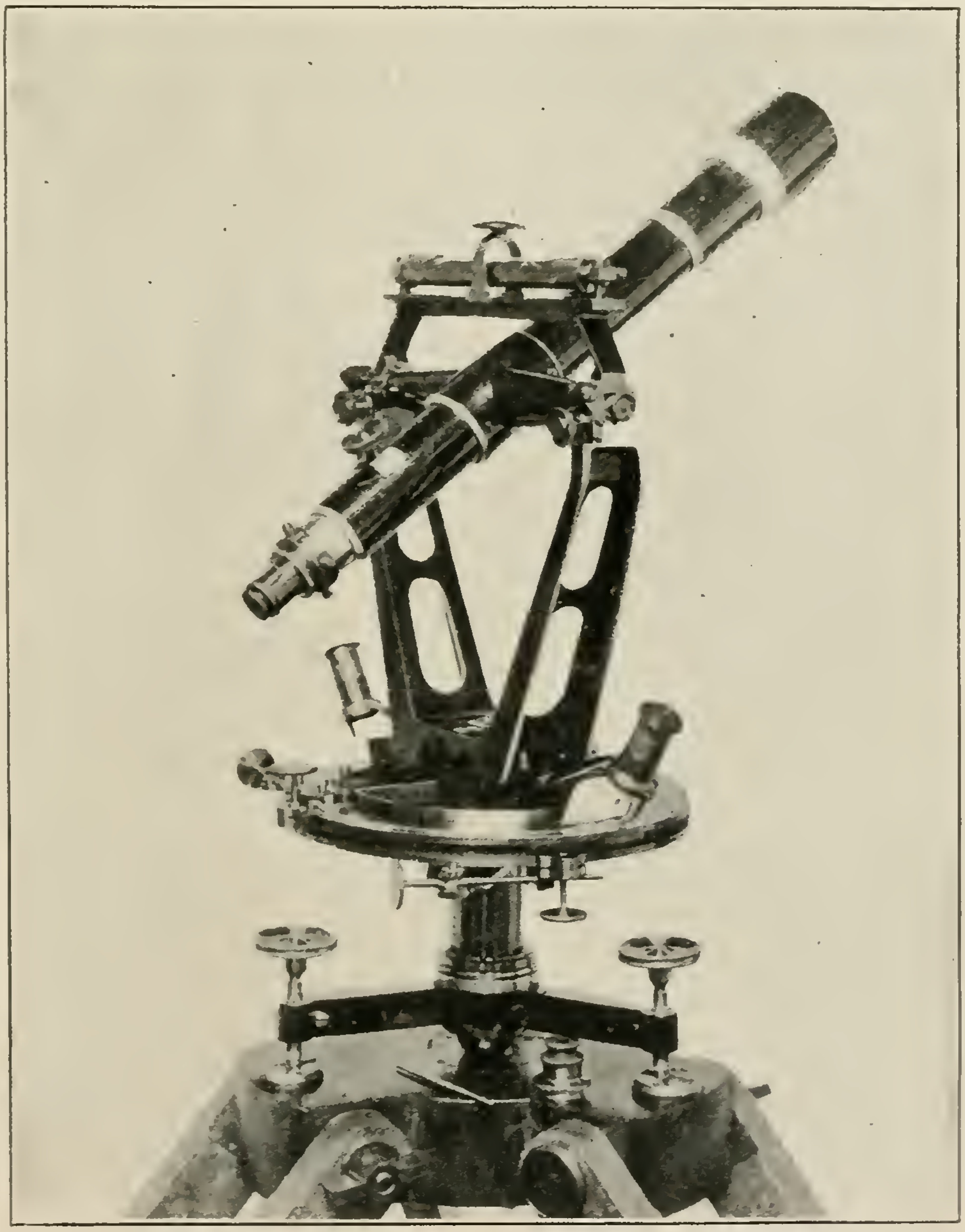
As soon as a section has been laid out into streets, and the design has been approved by the Borough President and the Board of Estimate and Apportionment, it becomes a portion of the official map, and is ready to be monumented. At present there are eight parties engaged on this work. Of these, five are employed in determining street lines and in setting points for monuments ; another places the stones in the ground, while the remaining two run traverses over the completed work, one doing the chaining and the other measuring the angles.

The monuments are composed of granite and measure 8″ x 8″ x 4′ 0″. The top is dressed with an eight cut hammer, and the sides are quarry faced with a 2″ draft at the top. Monuments are set at street intersections and at angle and curve points along offset lines parallel to and eight feet distant from the property. Where blocks are only 200 feet in width, a monument is buried at alternate streets only ; but where the length exceeds 500 feet they are placed at each street intersection. Where angles occur, they are buried on both sides of the street, on a bisecting line ; otherwise only one side is monumented. An offset distance of eight feet is employed as this brings the points between the curb and the property lines, where they are not exposed to vehicular traffic, and are far enough out from buildings and fences to avoid obstructions to vision, even where the encroachments are considerable. Monuments are set to the established grade wherever practicable. In the great majority of cases, however, this cannot be done ; and they are re-set while the work of grading is in progress. If however not more than eight inches below grade, the monuments are not disturbed ; but are covered with a cast iron shell, which fits around the top and supports a hinged cover at the level of the sidewalk.

In monumenting the older streets, where the original lines are re-



Telescope Heliotrope used by the U. S. C. & G. S. in the Primary Triangulation of New York City



Six-inch U. S. C. & G. S. Theodolite No. 29, used by the U. S. C. & G. S. in the Primary Triangulation of New York City

tained, a considerable portion of the time of the parties is taken up in ascertaining just where these street lines are. The usual procedure is to run a trial line from which offsets are measured to property line monuments, to surveyors' stakes, to the sides of buildings, when they appear to coincide with the lot lines, and as a last resort to fences. Front fences cannot be depended upon, as they are generally found to encroach upon the street, but the back fences, which form the division lines between lots, are much more reliable, since one owner or the other would be likely to take action if set erroneously. It very seldom happens however that the offsets are consistent ; and the engineer is forced to adopt a mean line, that harmonizes with the property as a whole, however much it may vary in individual cases.

The field work is carefully done so that the monuments will line up and the block lengths be consistent. In turning angles and prolonging lines, portable targets are used. These were designed by the Bureau and consist of a sighting board of the general appearance of a stadia rod, six feet high, painted with white diamond shaped panels on a black field, and having a central vertical groove, which terminates in a steel point. About six inches above the point, a pear shaped opening is provided in which a bob, suspended from the top can swing. When plumbed up over a point, the target is supported by a light extension tripod.

The preliminary chaining is done by means of a 50 or 100 foot catenary tape, with a spring balance and thermometer attached. In measuring long lines and in the final traversing, an apparatus is employed in which a 100 foot tape is supported at both ends and at the center, and the difference in elevation determined by level. On pavements and hard ground, cast iron stands, weighing thirty-five pounds each, and provided with smooth flat tops are used to form the supports. On rough ground steel bars, one inch in diameter are driven into the soil. These are encircled by sleeves which are clamped at any convenient height by means of set screws. The sleeves terminate in flat 6″ x 6″ plates. The rear end of the tape is attached to a brass chain. This is looped around a spike driven into the ground, after passing over a frame, adjusted to the height of the support to prevent drag. The chain is hooked up at any link so as to bring the zero scratch of the tape near the mark on the table, and the final adjustment is made by means of a small turnbuckle. The front end is provided with a spring balance, and the tape is uniformly stretched with a tension of ten pounds. The centre support consists of a rod perforated with

holes one inch apart, in which a nail is set on grade by sighting from one plate to the other. The plates are marked with a pencil, making a fine line. Pluses to stakes are measured from the nearest table with a plumb bob and tape. The temperature is read at each application. In going over a summit a broken chain length can be employed ; the man at the front end holding the 100 foot scratch on a point conveniently marked on the support, while the rear chainman marks the tape itself where it coincides with the point on his table ; after which the plus to the nearest twenty-five foot lug is measured with a tape. By using three supports no time is lost in leveling, even when turning points are required at every chain length. The speed varies from 1,000 to 2,000 feet an hour depending upon the ground and the number of pluses to be taken. The accuracy attained is almost entirely contingent upon the care with which the constant of the tape is determined and the closeness with which the temperature can be ascertained. As a rule the parties using this apparatus attain results rather better than 1 in 100,000. Tables are furnished giving equivalent horizontal distances for differences, of elevation up to 14 feet, as well as corrections for temperature, so that reductions can be made in the field. Notes are kept in the following form :

CHAINING ALONG ANKENER AVENUE

Measured Distances	Rod Read's and Diff. in Elev.	Temperature.	Horizontal Distances	Pluses and Tem. Corr's	Corrected Distances	
100	1.37 8.18 } 6.81	41.8°F.	99.768			
100	8.18 11.43 } 3.25	41.5	99 947			
50	1.02 6.17 } 5.15	41.2	49.734	249.449		
−18.397				−18.397		
		3)124 5		231.052		Station N. of Eliot Ave. to Mon. at Eliot Ave.
Temp. Corr.		41.5		— 0.030	231.022	
				+ 18.397		
100	6.17 10.44 } 4.27	41.0°	99 909			
100	−1.25 11 73 } 12.98	41 1	99 153			
100	11.73 8.45 } 3 28	41.3	99 947			
75	8 45 1.03 } 7.42	41.0	74 633			
61.834	11 92 −2.03 } 13.95	40.8	60.240			
25	−2.03 8.17 } 10.20	41.4	22.825	456.707		
+ 3.712				+ 3.712		
		6)246.6		478.816		Mon. at Eliot Ave. to Station N. of Jupiter Ave.
Temp. Corr.		41.1		— 0.063	478.753	
			706.156 + 3.712 — 0.093			
Temp. Corr.			709.775		709.775	

Note : The minus sign before a rod reading indicates that the H.I. is below the table.

When a street has been monumented, it is opened up at the request of the parties concerned, after the title has passed to the city. Title may be obtained either by voluntary gift in which the former owners pay the cost of the conveyance, or as the result of a judicial procedure. The latter is instituted when a petition is presented to a board composed of the Borough President and the aldermen residing within the

district. If adopted, the matter is carried to the Board of Estimate and Apportionment for their approval, who also decide what per cent, if any, of the cost is to be levied against the general fund. After passing this board, hearings are held before a commission of three members, appointed by the Supreme Court, who take testimony, examine the property to be condemned, and settle upon the awards to be made to owners. This commission also defines the limits within which property is to be assessed to pay the cost of the improvement, and reports back its findings to the Court. If the street opening is recommended and the Court approves, an order, is issued directing that the work be done. In case any of the property owners feel agrieved an appeal can be taken to the Appellate Division, and from there to the Court of Appeals for final review.

For the information of these various tribunals and to form a part of the permanent record, a number of maps are prepared by the Topographical Bureau. The first of these is called a "Rule Map", and consists of an outline of the street which is to be opened up with dimensions computed from the traverse distances between monuments. Where streets are on a curve, the measurements along the arc are given; also the distances to P. C. and P. T. Rule maps are made in quadruple form, and one copy is sent to the Corporation Council's office as soon as the opening proceedings are under way.

The next to be gotten out are the "Damage Maps." These are drawn to a scale of 50 or 60 feet to the inch and show the proposed street in its relation to existing lots and buildings. Lots and blocks are numbered and dimensioned, and where buildings project upon the street, the extent of each encroachment is shown to the nearest hundredth. Damage maps also contain a brief description of all such structures, and give the names of the property owners, and the areas to be taken.

The "Draft Benefit Maps" are the last to be compiled. These resemble the "Damage Maps", in form, but they are generally drawn to a smaller scale, and comprise one or more streets on both sides of the line of the proposed opening in order to include all of the property within the area to be assessed. This area is fixed by the commission and is outlined on the map. Benefit maps contain the lots and blocks with their numbers and dimensions, and where the contiguous streets have already passed into the possession of the city, this information is also given as well as the date and method by which the title was acquired.

Type of instrument without lenses, and with vernier reading to 5 minutes, used by John Randel, Jr., in laying out the streets of Manhattan, 1807-18 0

The Damage and Benefit Maps are based upon information obtained in part from the records of the tax office; and in part from surveys made by the Bureau, after the streets have been monumented. The Topographical Bureau also furnishes the Highway Department with the necessary plans to enable them to cut through the streets in accordance with the designs; and co-operates with the Department of Sewers in order that the grades may be made to conform to the probable drainage lines, and that both may harmonize with the topographical conditions.

The Topographical Bureau has been organized and the work is carried on under the direction of Mr. Robert R. Crowell, Engineer in charge. Mr. H. K. Endemann has control of the preliminary surveys and Mr. J. H. Weinberger of the monumenting; while the Cornell men who hold positions of responsible charge include Messrs. E. W. Firth, '95, C. U. Powell, '98, and W. L. Savacool, '04.

THE HYDRAULIC LABORATORY OF CORNELL.

E. W. SCHODER,
Assistant Professor of Experimental Hydraulics.

In the Engineering News of March 2, 1899, there appeared a description of the then new hydraulic laboratory of Cornell University. It has been said that a university uses a decade as the unit for measuring time, and as it is now just about ten years since plans were drawn up for the laboratory structures, it is interesting to examine the present status of this unique part of Cornell's facilities.

Those interested in the problems of hydraulic engineering are aware of the excellent work that has been done in the canal above the laboratory building. Many studies on the flow of water over weirs and dams have been made. Public and private interests alike have availed themselves of this part of the equipment. Nevertheless it is true that much of this work has been done under commercial pressure for results to be available immediately, and science has not gained as much as it might have done.

A test is an important matter. The finding by experiment of the correct coefficients to use has been and is a fundamental part of modern engineering. But it is hardly true that the sciences that underlie engineering depend on commercial tests except as these have in them elements of research.

This distinction between testing and experimental research is at times vague and at other times very clearly defined. Each has elements of the other. The necessity for each in large part springs from the other. It appears to be almost true that the attitude of the worker makes the difference between a test and a piece of research work. It is beyond question that this attitude can change the character of a laboratory.

I have dwelt a little on this point because it so concerns the future of the Cornell University Hydraulic Laboratory. Experimental hydraulics has to do with commercial testing and with pure physical science at once. It certainly comes from a low view of engineeing to limit by present urgent needs the scope of any experimental investigation except a test pure and simple. And it is a rather visionary study that has in its results no elements of probable usefulness to mankind generally.

General View of the Hydraulic Laboratory in May, 1906.

For seven years after its construction, or until a year ago, the laboratory building was practically unused. The 6 ft. steel standpipe, 65 ft. high, within the building, with all the opportunities for investigations almost impossible without this piece of equipment, was doing no useful service.

At present all experimental hydraulic work including class work is done in Fall Creek gorge. The old laboratory in Lincoln Hall basement is no more. This removal of all work to the gorge marks a step forward.

Class instruction can now be given satisfactorily along more lines than formerly, especially for the elective senior courses. This is demanded by the advance in the science of hydraulics, for what a few years ago was considered highly specialized knowledge is now a necessary part of every hydraulic engineer's education. And at Cornell the facilities allow the class experimental work to cover a range of conditions as great as is met with in ordinary practice. Under such conditions actual experimentation and the subsequent computations and reports have an enhanced value for the student.

Thesis investigations can be carried on along many lines. The availability of large quantities of water and a great range of heads, the feasibility of setting up apparatus to meet an endless variety of circumstances,—all contribute to the unique resources of the laboratory. The student can select work that appeals to his mind. Thus personal interest is secured and all the rest takes care of itself. Especially is this true when, as is always desirable, the investigation enters unexplored fields, and the student assumes the responsibility of a pioneer.

Qualities of independent thought and action develop rapidly through experimental thesis work. The student acquires faith in his strength and realizes his weak points. He becomes receptive and perhaps gets the first inkling of the real meaning of study.

During the last year a number of thesis investigations, by seniors and graduate students, that are important contributions to hydraulic science have been carried on. Inasmuch as the results probably will be published in engineering periodicals, they will not be discussd here.

The development of the laboratory and the starting of class work with the new facilities has temporarily checked special research investigations along many desirable lines. But it may be stated that several such studies are planned for the near future.

Commercial testing in the past has been mostly along the lines of the flow of water over weirs. Some work in the rating of current meters and the testing of small hydraulic motors has been done.

It is hoped that during the coming summer the facilities for testing large hydraulic machinery will be improved. This can be done readily. Also it is planned that the arrangement of the equipment at the bottom of the laboratory building shall be changed so that in a fuller sense the facilities may be made available for investigations of many kinds.

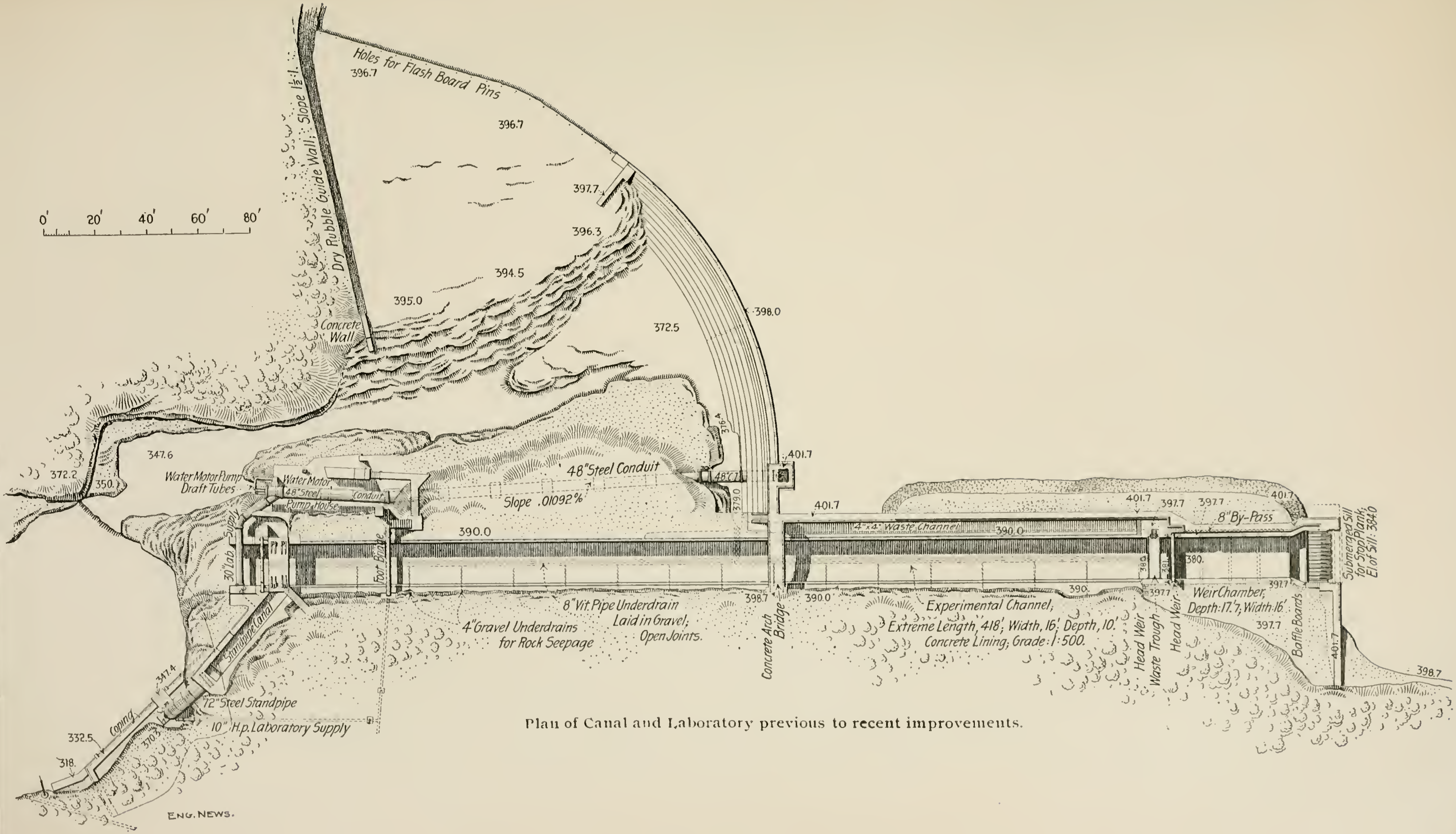
The 48 inch steel pipe just below Beebe dam is now entirely turned over to the hydraulic laboratory. Formerly it supplied the old water pressure engine pumps that pumped water to the university filtration plant. The university water supply is now pumped by electric motor driven centrifugal pumps located near the experimental canal headgates.

The 48 inch pipe has been used to supply the 6 ft. standpipe canal inside the laboratory building when it was desired to use the 16 ft. canal for other purposes. In addition to this use, many kinds of apparatus can now be attached to and supplied by the 48 inch pipe. The pressure is very steady as the pipe is fed directly by Beebe Lake.

Also the old pump house furnishes additional space where large quantities of water under pressures up to 10 lbs. are available. The old cast iron pipe line attached to the lower end of the 48 in. steel pipe and formerly used to feed the water pressure engine pumps will be preserved, and when the pumps are removed it will be a valuable piece of equipment for experimental uses.

For this and last college year class experiments on the flow of water in pipes have been made on 4 in., 5 in. and 6 in. pipe lines laid along the bottom of an excavation between the canal and the 48 in. steel main. The loss of head experiments on several kinds of pipes and the Pitot tube work have been very satisfactory. The availability of the 48 in. pipe and the old pump house adds to the facilities for pipe flow experiments.

Viewed in a general way the hydraulic laboratory presents a peculiar condition of affairs. The most remarkable facilities are available with very little cost for development and almost none for maintenance. An appearance of crudeness is everywhere apparent. This is due as much to the large size and the exposed condition of the equipment as to a state of incomplete development. Thus, to house the canal and 48 in. pipe would require a building 450 ft. long by 50 ft. wide. Such a structure would enable work to go on all winter and in stormy weather at which times experimental work under present conditions must stop. But in good weather for eight months of the year the canal is now available. This is true also of the other exposed equipment.



Plan of Canal and Laboratory previous to recent improvements.

Now that use is being made of the laboratory building with arrangements for heating during the winter, it seems that a combination of open air work with indoor work can be brought about that will be very satisfactory.

It may be well in closing to enumerate briefly the facilities that are actually available at the present time.

The experimental canal has been well described elsewhere.* Besides its use for comparative weir experiments, it has served as a feeder for the 6 ft. standpipe canal and as a still water basin for rating current meters. The department of Marine Engineering has used it as a basin for studying propellers. For these two last named uses the electric motor car spanning the canal is used.

There is a 4 ft. by-pass tunnel passing longitudinally through the wing dam or retaining wall along the north side of the canal. This was built with the idea of using the lower part of the canal as a measuring basin. This combination of waste way and measuring basin has not yet been used, although it is a special feature of the general design. Volumetric measurements of large discharges over weirs or model dams or through flumes constructed in the upper weir chamber can be made by using this special equipment. Only an adequate diverting apparatus is necessary to render it available.

The 48 in. steel main below the dam has been mentioned before. It furnishes water to the standpipe canal independently of the 16 ft. canal when this is desirable. A few thousand dollars would extend this pipe down into the laboratory building and give a water supply for hydraulic machinery or other purposes under 80 ft. head. This would leave the standpipe free for any other uses. It is an improvement that probably will become urgent in a few years.

The 6 ft. steel standpipe has been used much for class work and for special investigations during the past year. It is all that it was designed to be. Nozzles can be attached anywhere for permanent or temporary attachment of apparatus. The standpipe has not yet been used as a measuring basin for experiments in the 6 ft. canal, but some weir experiments are planned in which advantage will be taken of this use. Its capacity is about 1700 cu. ft.

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* Rafter's "On the Flow of Water over Dams." Trans. Am. Soc. C. E., Vol. XLIV, 1900, page 285. John R. Freeman's "Report on New York's Water Supply" 1900, page 130. Eng. News, March 2, 1899.

The special advantage of this standpipe over others lies in the availability of a very steady supply of water with no necessity for expensive pumping and in quantities as large as 150 cu. ft. per sec. For a very small expense a steel turbine testing flume can be attached. Such a flume would enable wheels of 500 H.P. under 60 ft. head to be studied.

Early this summer a steel concrete roof is to be placed on the laboratory building. This will be arranged to intercept seepage from the rocks of the cliff above. A concrete floor is planned for the 2d floor where the Junior Laboratory apparatus is situated. These changes will make the building a more pleasant working place.

Considering the present established facilities together with the proposed improvements the future usefulness of the laboratory along many lines seems assured.

SHORT PROCESS FOR DIVIDING NEUTRAL AXIS IN CONCRETE STEEL ARCHES.

(*Based on Method Given by Wm. Cain, M. Am. Soc. C. E.*)

M. HAUPT, CORNELL, '06.

COMPILATION OF TABLES.

This portion of the thesis will treat of the compilation of tables computed from the formula

$$\frac{1}{12}d^3 + K\left(\frac{d}{2} - C\right)^2 \quad \text{(See Wm. Cain's book, page 36.)}$$

The formula is nothing more or less than the moment of inertia of a rectangle + the moment of inertia of a small area K at a distance of $\left(\frac{d}{2} - C\right)$ from the neutral axis of the rectangle. The moment of inertia of the small area K about its own gravity axis is neglected since it is very small.

The above formula is a generalization of the formula given for a particular case on page 36 of Wm. Cain's book.

In the above formula, we have three variables; $d =$ depth of the arch ring, and K and C, both dependent on the amount of reinforcement and the distance this reinforcement is placed from the intrados and extrados of the arch ring; this latter is designated by C; K is the the sectional area of the reinforcement multiplied by the ratio of the modulus of elasticity of the material of which the reinforcement is composed to that of the concrete or whatever else the arch ring is made of.

If now, we make out a table for the above formula, in which d is a constant, we shall have only two variables K and C in that particular table. If now, we put down various values of K in a vertical column, for this table, and we proceed to evaluate the formula for the various values of C, which values of C are placed at the top in horizontal lines, the values of C for any particular column of this table will, of course be constant.

Now let us examine the formula again, under our new assumptions and see what we have. For the purpose of greater facility in handling this formula, we will express it thus:

$$\frac{1}{12}d^3 + K\left(\frac{d}{2} - C\right)^2 = \int(d). \qquad (1)$$

Since, as was shown above, d and C are both constant for any one vertical column of any one table; *i. e.*, for any particular value of d, (1) may be written thus :—

$$y = Ax + B, \qquad (2)$$

in which $y = (d)$; $X = K$; $A = \left(\frac{d}{2} - C\right)^2$ = a constant.

But (2) is a straight line equation; therefore, for any particular vertical column for any one value of d, it is necessary to evaluate the formula for only the first value of K; the next value of the formula being obtained by simply adding to the first value n times $\left(\frac{d}{2} - C\right)^2$; where n is the number by which K varies. For instance, in the tables compiled, this number is .01 and .02.

In the tables herein incorporated, the values for $\frac{1}{12} d^3$ from $d = .5$ ft. to $d = 7$ ft. inclusive are evaluated for intervals of .05 ft. and .1 ft. Also the quantities $\left(\frac{d}{2} - C\right)^2$ for various values of d and C used are tabulated; these tables, of course, being simply to facilitate the computation of the other tables. Also, the common difference for each column will be found at the foot of that column, so that the table may be extended to any point desired.

The values of d and K were taken for most cases that are liable to come up in ordinary practice. The values of C were taken in conformance to the rule stating that when the depth of the arch ring is one foot deep the reinforcement should be placed 2 inches from the intrados and extrados respectively; and when it is 7 ft. deep the reinforcement should be placed 5″ from the intrados and extrados respectively.

From the manner of computing these tables, it is seen that if constant differences be added to each value to obtain the next lower value, the last value may be checked by computing it. This was actually done, and, so far as this check goes, the tables are *absolutely* correct so far as carried out.

The convenience of such tables when it is necessary to design several arches or where several designs of the same arch are made can be appreciated only by the person actually doing such work.

Note.—In order to condense this article as much as possible, only a few tables are incorporated in their entirety; those for $d = 1.40$ ft., $d = 1.45$ ft., $d = 1.50$ ft., $d = 1.60$ ft., $d = 1.70$ ft.

As for the other tables, the value of I for only one value of K is given together with the difference for $K = 0.01$, so that any other value of I, corresponding to a different value of K can be obtained by simply multiplying the difference between the given K and the required K into the constant difference for $K = .01$, and adding to the value of I for the given K. The tables in as much detail as those herein incorporated for $d = 1.4$ to 1.70 can be found in the writer's thesis; the tables cover values of d from 0.5 to 7.00 ft.

Example:—

Suppose the depths of the arch ring to be as follows.

d, at crown = 1.5
d, 2 ft. from crown on neutral axis = 1.6
d, 4 ft. " " " " " = 1.7
etc., etc., etc.

Let us take the reinforcement to be 1/150 of the section of the arch ring at the crown; then, for one foot width of the arch ring, we have 1/150 x 1.5 sq. ft. = 0.01 sq. ft. of reinforcement. Let us take the ratio of the modulus of elasticity of steel to that of concrete to be 20; then, the equivalent area of steel reinforcement, if reduced to concrete, is 20 x 0.01 sq. ft. = 0.2 sq. ft.; this is the term K in the tables.

Also, in conformance with the rule stated before, the reinforcement will be placed $2'' + \left(\frac{0.5}{6} \times 3''\right) = 2''.25$ from the intrados and extrados; and $2''.25 = .18$ ft.; this is the term C in the tables. (The nearest value of C in the tables for this depth is .17 ft., which gives no appreciable error).

The two terms K and C above determined remain constant throughout the arch ring generally, but two values of C are given for every value of d, so as to allow some leeway.

Looking into the tables now with $d = 1.5$ as argument and $K = 0.2$ and $C = .17$, we get the value of the formula given at the beginning of this article, which is the moment of inertia of the section at the crown, 0.348530 ft.^{4}

Taking now our next value of $d = 1.6$, with the same value of K and either .17 or .20 for C (very little error either way), we get for value of I, 0.420824 ft.^{4}; for $d = 1.7$, $I = 0.501896$ ft.^{4}, and so on just as fast as the d's can be scaled off.

These tables will enable a person to take out quickly the moment inertia corresponding to any d in the arch ring.

GRAPHICAL METHOD OF DIVIDING THE NEUTRAL AXIS.

(*F. Kurtz and F. Sherman, Cornell '07.*)

The neutral axis is now divided into two foot sections and the corresponding *d's* measured; the *I's* corresponding to these *d's* are taken from the table, and a curve plotted with $S =$ distances along neutral axis as abscissae, and I for ordinates; the length of one-half the neutral axis is thus plotted and a curve obtained. Take for the length of the first S about 24% of the half length of the neutral axis, and erect an isosceles triangle *OAB*, and continue to draw similar isosceles triangles *BCD*, *DEF*, etc. (Fig. 1) until the end of the neutral axis in the crown section is reached; the condition $\frac{S}{I} =$ constant throughout the arch ring shall then have been satisfied, providing the end of the base of the last triangle comes in a vertical line drawn through the point on the curve corresponding to that of the neutral axis at the crown. If this be not the case, put one-third of the discrepancy in S_1, and repeat the process; a satisfactory division is generally obtained upon the second trial. (It is assumed here that the first S was laid off from the skew back toward the crown).

The proof of the above is very simple. The triangles are similar, and, since their bases are the various *S's* and their altitudes the corresponding *I's* at the middle of these *S's*, we have $\frac{S_1}{I_1} = \frac{S_2}{I_2}$ constant throughout the arch ring.

It is believed that with the combination of the two methods above proposed, the neutral axis can be divided satisfactorily in a very much shorter time than could otherwise be done.

Graphic Subdivision
of Neutral Axis of
Concrete-Steel Arch Ring.

F. Kurtz.
F. E. Sherman.

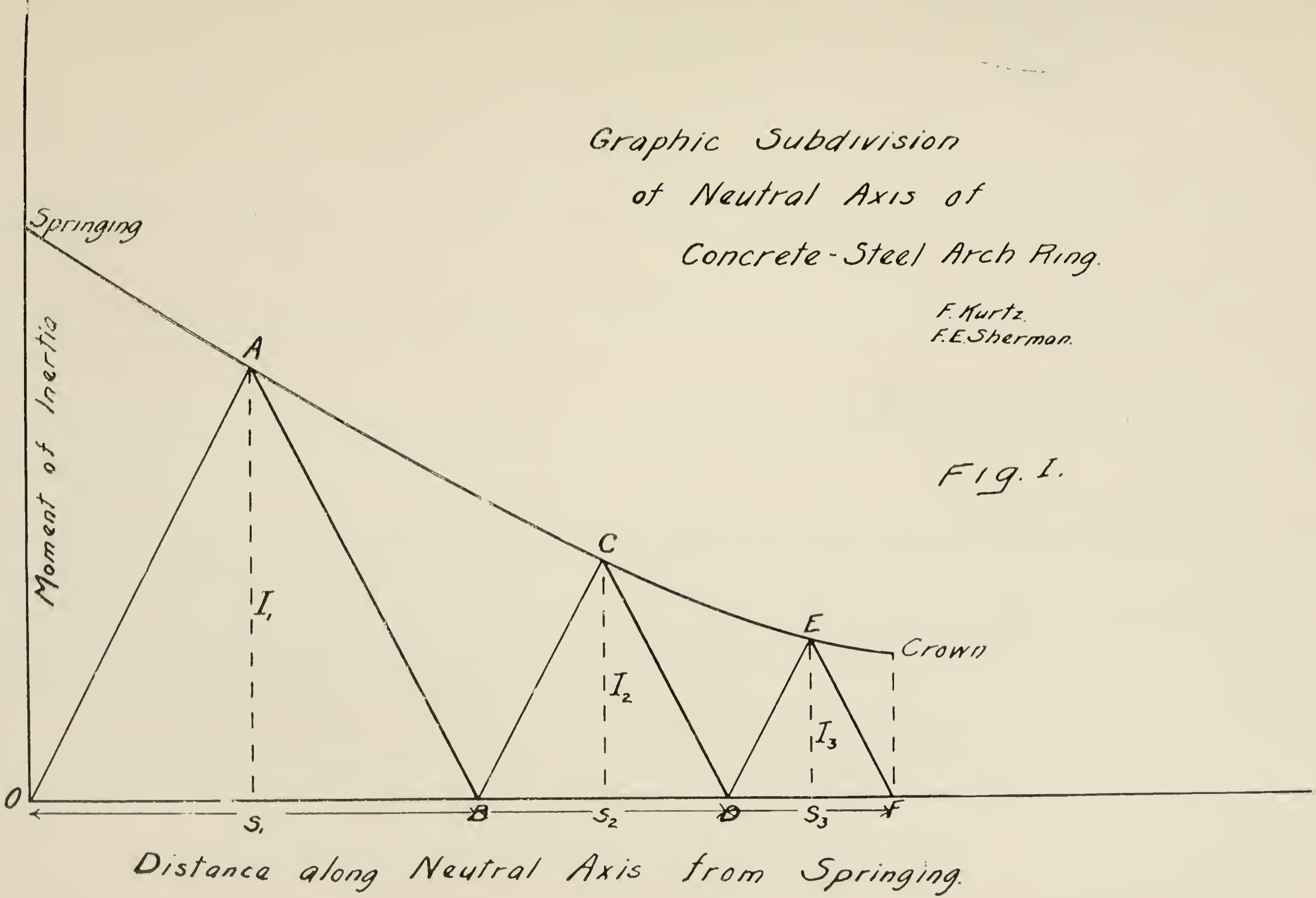

Fig. I.

	Table $d=1.40$		Table $d=1.54$		Table $d=1.50$	
K	$C=.15$	$C=.17$	$C=.15$	$C=.17$	$C=.15$	$C=.17$
.05	.243792	.242712	.270583	.269453	.29925	.298070
.06	.246817	.245521	.273889	.272533	.30285	.301434
.07	.249842	.248330	.277195	.275613	.30645	.304798
.08	.252867	.251139	.280502	.278694	.31005	.308162
.09	.255892	.253948	.283808	.281774	.31365	.311526
.10	.258917	.256757	.287114	.284854	.31725	.314890
.11	.261942	.259566	.290420	.287934	.32085	.318254
.12	.264967	.262375	.293727	.291014	.32445	.321618
.13	.267992	.265184	.297033	.294095	.32805	.324982
.14	.271017	.267993	.300339	.297175	.33165	.328346
.15	.274042	.270802	.303645	.300255	.33525	.331710
.16	.277067	.273611	.306952	.303335	.33885	.335074
.17	.280092	.276420	.310258	.306416	.34245	.338438
.18	.283117	.279229	.313564	.309496	.34605	.341802
.19	.286142	.282038	.316870	.312576	.34965	.345166
.20	.289167	.284847	.320177	.315657	.35325	.348530
.21	.292192	.287656	.323483	.318737	.35685	.351894
.22	.295217	.290465	.326789	.321817	.36045	.355258
.23	.298242	.293274	.330095	.324897	.36405	.358622
.24	.301267	.296083	.333402	.327978	.36765	.361986
.25	.304292	.298892	.336708	.331058	.37125	.365350
.26	.307317	.301701	.340014	.334138	.37485	.368714
.27	.310342	.304510	.343320	.337218	.37845	.372078
.28	.313367	.307319	.346627	.340299	.38205	.375442
.29	.316392	.310128	.349933	.343379	.38565	.378806
.30	.319417	.312937	.353239	.346459	.38925	.382170
Diff. =	.003025	.002809	.003306	.003080	.0036	.003364

	Table $d=1.6$		Table $d=1.7$		Table $d=1.8$	
K	$C=.17$	$C=.20$	$C=.17$	$C=.20$	$C=.17$	$C=.20$
.05	.361288	.359444	.432536	.430541	.512645	.506
.06	.365258	.363044	.437160	.434766	.517974	.510
.07	.369227	.366644	.441784	.438991	.523303	.514
.08	.373196	.370244	.446408	.443216	.528632	.518
.09	.377165	.373844	.451032	.447441	.533961	.522
.10	.381134	.377444	.455656	.451666	.539290	.526
.11	.385103	.381044	.460280	.455891	.544619	.530
.12	.389072	.384644	.464904	.460116	.549948	.534
.13	.393041	.388244	469528	464341	.555277	.538
.14	.397010	.391844	.474152	.468566	.560606	.542
.15	.400979	.395444	.478776	.472791	.565935	.546
.16	.404948	.399044	.483400	.477016	.571264	.550
.17	.408917	.402644	.488024	.481241	.576593	.554
.18	.412886	.406244	.492648	.485466	.581922	.558
.19	.416855	.409844	.497272	.489691	.587251	.562
.20	.420824	.413444	.501896	.493916	.592580	.566
.21	.424793	.417044	.506520	.498141	.597909	.570
.22	.428762	.420644	.511144	.502366	.603238	.574
.23	.432731	.424244	.515768	.506591	.608567	.578
.24	.436700	.427844	.520392	.510816	.613896	.582
.25	.440669	.431444	.525016	.515041	.619225	.586
.26	.444638	.435044	.529640	.519266	.624554	.590
.27	.448607	.438644	.534264	.523491	.629883	.594
.28	.452576	.442244	.538888	.527716	.635212	.598
.29	.456545	.445844	.543512	.531941	.640541	.602
.30	.460514	.449444	.548136	.536166	.645870	.606
Diff. =	003969	.0036	.004624	.004225	.005329	.004000

	$d=0.5$ ft.		$d=0.6$ ft.		$d=0.7$ ft.	
K	$C=.15$	$C=.17$	$C=.15$	$C=.17$	$C=.15$	$C=.17$
.05	.010916	.010736	.014645	.014415	.019125	.018845
Diff. for $K=.01$	.000156	.000110	.000156	.000110	.000225	.000169
	$d=.65$ ft.		$d=.70$ ft.		$d=.75$ ft.	
K	$C=.15$	$C=.17$	$C=.15$	$C=.17$	$C=$ 15	$C=.17$
.05	.024416	.024086	.030583	.030203	.037687	.037257
Diff. for $K=.01$	.000306	.000240	.000400	.000324	.000506	.000420
	$d=.80$ ft.		$d=.85$ ft.		$d=.90$ ft.	
K	$C=.15$	$C=.17$	$C=.15$	$C=.17$	$C=.15$	$C=.17$
.05	.045725	.045245	.054958	.054428	.06525	.064670
Diff. for $K=.01$	.000625	.000529	.000756	.000650	.0009	.000784
	$d=.95$ ft.		$d=1.00$ ft.		$d=1.05$ ft.	
K	$C=.15$	$C=.17$	$C=.15$	$C=.17$	$C=.15$	$C=.17$
.05	.076729	.076099	.089458	.088778	.103500	.102770
Diff. for $K=.01$	.001056	.000930	.001225	.001089	.001406	.001260
	$d=1.10$ ft.		$d=1.15$ ft.		$d=1.2$ ft.	
K	$C=.15$	$C=.17$	$C=.15$	$C=.17$	$C=.15$	$C=.17$
.05	.118916	.118136	.135770	.134940	.154125	.153245
Diff. for $K=.01$	.0016	.001444	.001806	.001640	.002025	.001849
	$d=1.25$ ft.		$d=1.3$ ft.		$d=1.35$ ft.	
K	$C=.15$	$C=.17$	$C=.15$	$C=.17$	$C=.15$	$C=.17$
.05	.174042	.173112	.195583	.194603	.218812	.217782
Diff. for $K=.01$	.002256	.002070	.0025	.002304	.002756	.002550
	$d=1.4$ ft.		$d=1.45$ ft.		$d=1.5$ ft.	
K	$C=.15$	$C=.17$	$C=.15$	$C=.17$	$C=.15$	$C=$ 17
.05	.243792	.242712	.270583	.269453	.29925	.298070
Diff. for $K=.01$	.003025	.002809	.003306	.003080	.0036	.003364
	$d=1.6$ ft.		$d=1.7$ ft.		$d=1.8$ ft.	
K	$C=.17$	$C=.20$	$C=.17$	$C=.20$	$C=.17$	$C=.20$
.05	.361288	.359444	.432536	.430541	.512645	.506
Diff. for $K=.01$	.003969	.0036	.004624	.004225	.005329	.004000
	$d=1.9$ ft.		$d=2.00$ ft.		$d=2.1$ ft.	
K	$C=.17$	$C=.20$	$C=.17$	$C=.20$	$C=.17$	$C=.20$
.05	.602004	.599709	.701112	.698667	.810470	.807875
Diff. for $K=.01$	.006084	.005625	.006889	.0064	.007744	.007225
	$d=2.2$ ft.		$d=2.3$ ft.		$d=2.4$ ft.	
K	$C=.17$	$C=.20$	$C=.17$	$C=.20$	$C=.17$	$C=.20$
.05	.930578	.927833	1.061937	1.059042	1.205045	1.202
Diff. for $K=.01$	.008649	.0081	.009604	.009025	.010609	.01000
	$d=2.5$ ft.		$d=2.6$ ft.		$d=2.7$ ft.	
K	$C=.20$	$C=.22$	$C=.20$	$C=.22$	$C=.22$	$C=.24$
.05	1 357205	1.355725	1.525167	1.522987	1.704095	1.701855
Diff. for $K=.01$	.011025	.010609	.0121	.011664	.012769	.012321
	$d=2.8$ ft.		$d=2.9$ ft.		$d=3.00$ ft.	
K	$C=.24$	$C=.26$	$C=.24$	$C=.26$	$C=.26$	$C=.28$
.05	1.896613	1.894313	2.105622	2.103222	2.326880	2.324420
Diff. for $K=.01$	.013456	.012996	.014641	.014161	.015376	.014884
	$d=3.1$ ft.		$d=3.2$ ft.		$d=3.3$ ft.	
K	$C=.26$	$C=.28$	$C=.26$	$C=.28$	$C=.28$	$C=.30$
.05	2 565788	2.563228	2.820447	2.817787	3.088595	3.085875
Diff. for $K=.01$	.016641	.016129	.017956	.017424	.018769	.018225

	$d=3.4$ ft.		$d=3.5$ ft.		$d=3.6$ ft.	
K	$C=.28$	$C=.30$	$C=.30$	$C=.32$	$C=.30$	$C=.32$
.05	3.376153	3.373333	3.678042	3.675162	4.00050	3.997520
Diff. for $K=.01$	.020164	.0196	.021025	.020449	.0225	.021904
	$d=3.7$ ft.		$d=3.8$ ft.		$d=3.9$ ft.	
K	$C=.30$	$C=.32$	$C=.30$	$C=.32$	$C=.30$	$C=.32$
.05	4.341208	4.338128	4.700667	4.697487	5.079375	5.076095
Diff. for $K=.01$	.024025	.023409	.0256	.024964	.027225	.026569
	$d=4.00$ ft.		$d=4.1$ ft.		$d=4.2$ ft.	
K	$C=.30$	$C=.32$	$C=.30$	$C=.32$	$C=.30$	$C=.32$
.05	5.477833	5.474453	5.896542	5.893062	6.33600	6.332420
Diff. for $K=.01$	.0289	.028224	.030625	.029929	.0324	.031684
	$d=4.4$ ft.		$d=4.5$ ft.		$d=4.6$ ft.	
K	$C=.30$	$C=.32$	$C=.30$	$C=.32$	$C=.32$	$C=.34$
.05	7.279157	7.275387	7.783875	7.779995	8.307353	8.303413
Diff. for $K=.01$	.0361	.035344	.038025	.037249	.039204	.038416
	$d=4.7$ ft		$d=4.8$ ft.		$d=4.9$ ft.	
K	$C=.32$	$C=.34$	$C=.32$	$C=.34$	$C=.32$	$C=.34$
.05	8.857962	8.853922	9.432320	9.428180	10.030928	10.026688
Diff. for $K=.01$	.041209	.040401	.043264	.042436	.045369	.044521
	$d=5.00$ ft.		$d=5.1$ ft.		$d=5.2$ ft.	
K	$C=.32$	$C=.34$	$C=.34$	$C=.36$	$C=.34$	$C=.36$
.05	10.654287	10.649947	11.298455	11.294055	11.972713	11.968213
Diff. for $K=.01$	.047524	.046656	.048841	.047961	.051076	.050176
	$d=5.3$ ft.		$d=5.4$ ft.		$d=5.5$ ft.	
K	$C=.34$	$C=.36$	$C=.34$	$C=.36$	$C=.34$	$C=.36$
.05	12.673222	12.668622	13.400480	13.395780	14.154988	14.150188
Diff. for $K=.01$	.053361	.052441	.055696	.054756	.058081	.057121
	$d=5.6$ ft.		$d=5.7$ ft.		$d=5.8$ ft.	
K	$C=.36$	$C=.38$	$C=.36$	$C=.38$	$C=.36$	$C=.38$
.05	14.932347	14.927487	15.742755	15.737795	16.581913	16.576853
Diff. for $K=.01$	.059536	.058564	.062001	.061009	.064516	.063504
	$d=5.9$ ft.		$d=6.0$ ft.		$d=6.1$ ft.	
K	$C=.36$	$C=.38$	$C=.36$	$C=.38$	$C=.36$	$C=.38$
.05	17.450322	17.445162	18.348480	18.343220	19.276888	19.271528
Diff. for $K=.01$	.067081	.066049	.069696	.068644	.072361	.071289
	$d=6.2$ ft.		$d=6.3$ ft.		$d=6.4$ ft.	
K	$C=.36$	$C=.38$	$C=.36$	$C=.38$	$C=.38$	$C=.40$
.05	20.236047	20.230587	21.226455	21.220895	22.242950	22.237333
Diff. for $K=.01$	.075076	.073984	.077841	.076729	.079524	.0784
	$d=6.5$ ft.		$d=6.6$ ft.		$d=6.7$ ft.	
K	$C=.38$	$C=.40$	$C=.38$	$C=.40$	$C=.38$	$C=.40$
.05	23.297262	23.291542	24.384320	24.378500	25.504628	25.498708
Diff. for $K=.01$	.082369	.081225	.085264	.084100	.088209	.087025
	$d=6.8$ ft.		$d=6.9$ ft.		$d=7.00$ ft.	
K	$C=.38$	$C=.40$	$C=.40$	$C=.42$	$C=.40$	$C=.42$
.05	26.658687	26.652667	27.840875	27.834795	29.063833	29.057653
Diff. for $K=.01$	.091204	.090000	.093025	.091809	.096100	.094864

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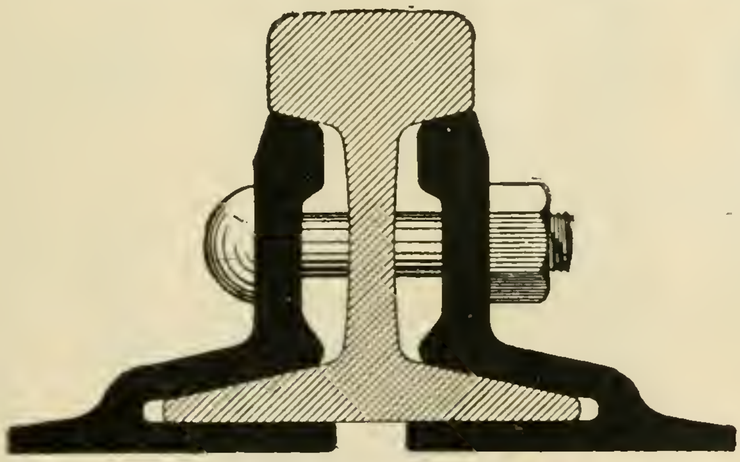

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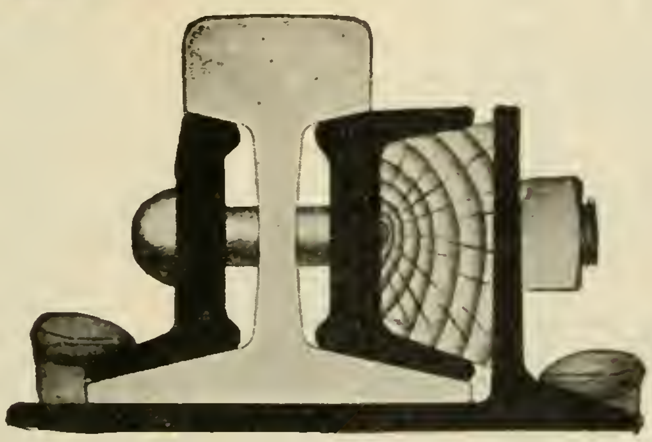

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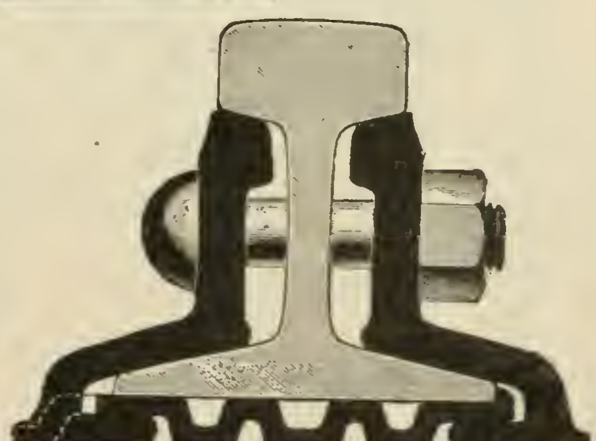

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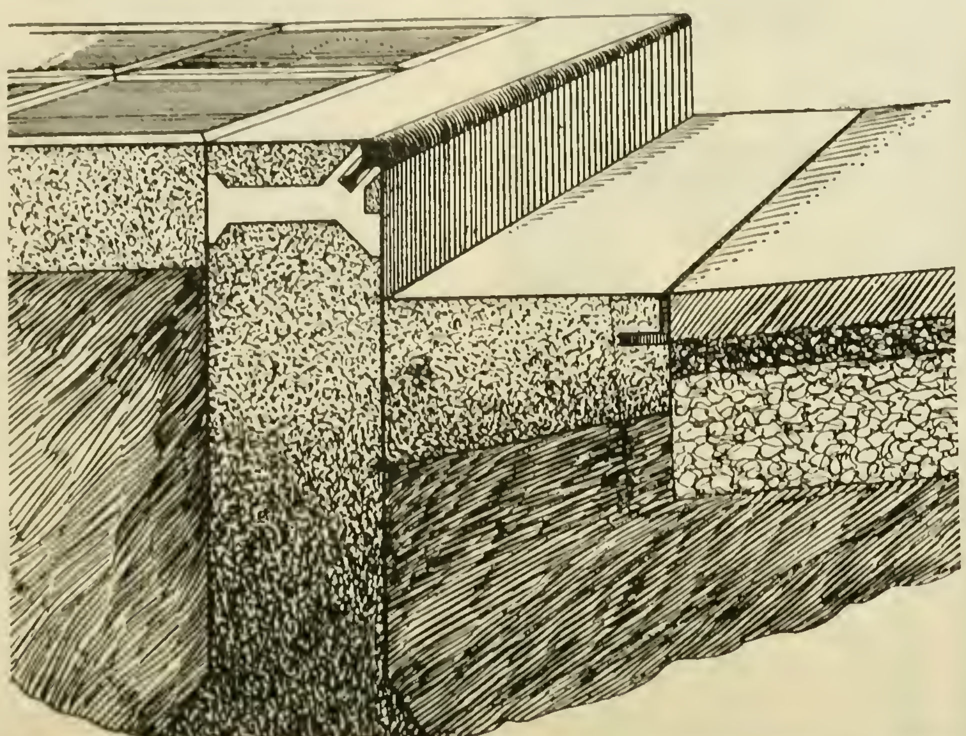

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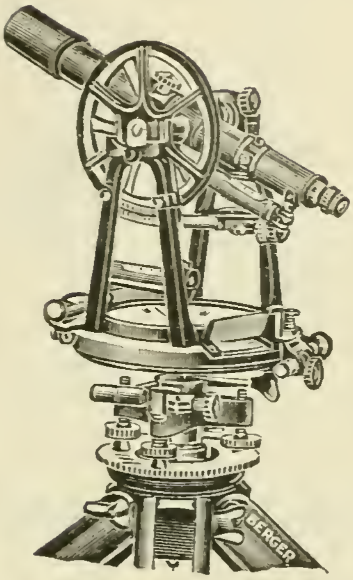

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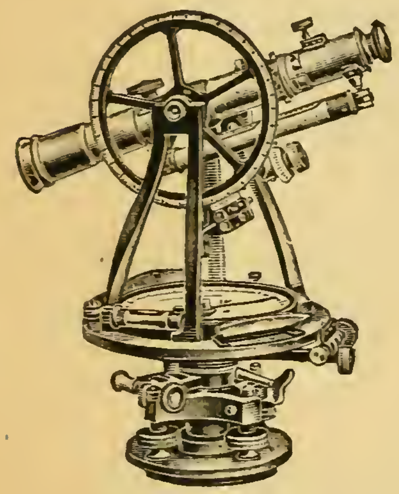

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